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APPENDIX A

DISSOLVED AIR FLOTATION

PHASE 1 - PRE-CONSTRUCTION STUDIES ON QUALITY AND QUANTITY RELATIONSHIPS OF COMBINED SEWAGE FLOWS AND RECEIVING WATER STUDIES AT OUTER MARINA BEACH

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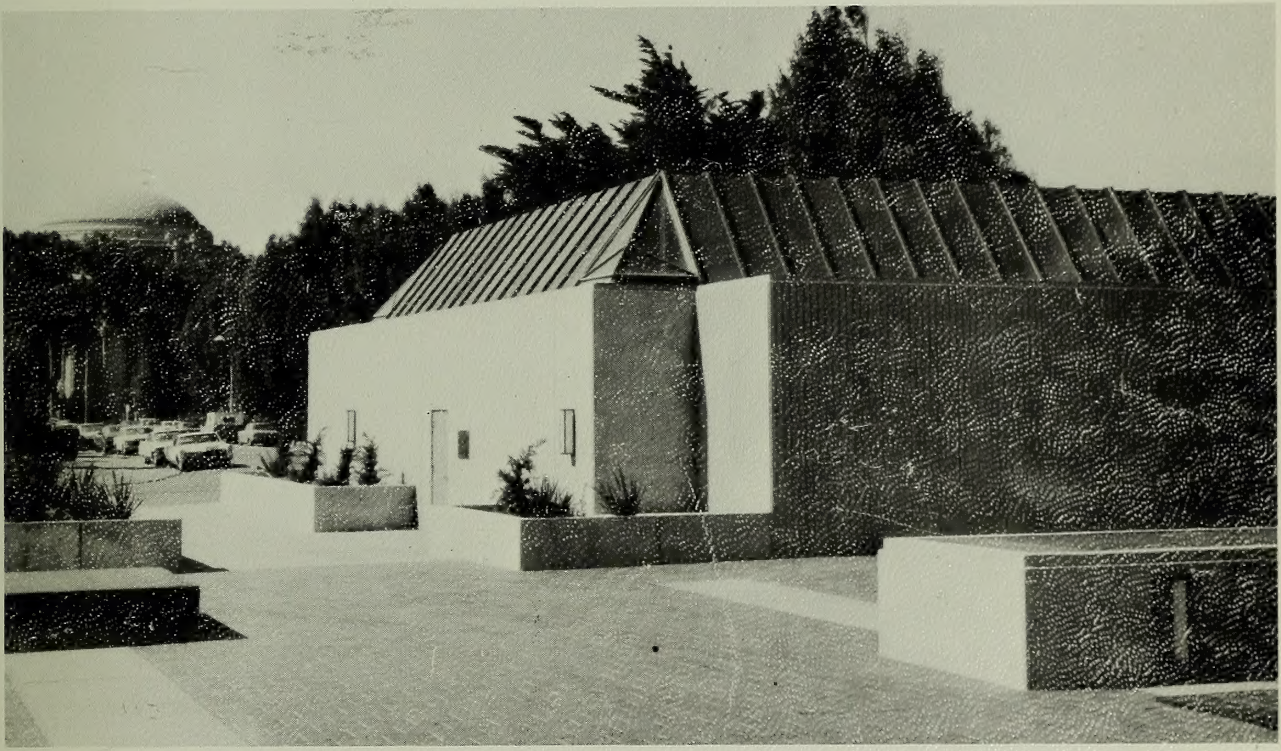

JULY 1971

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DISSOLVED AIR FLOTATION

APPENDIX A

PHASE I - PRE-CONSTRUCTION STUDIES ON QUALITY AND QUANTITY RELATIONSHIPS OF COMBINED SEWAGE FLOWS AND RECEIVING WATER STUDIES AT OUTER MARINA BEACH

Part of City and County of San Francisco's
Master Plan Study for Wet Weather Control Program

submitted by

City and County of San Francisco, California

prepared by

Engineering-Science, Inc.
Research and Development Laboratory/Berkeley

for

Environmental Protection Agency
Water Quality Office

July 1971

FOREWORD

This volume constitutes the first of seven technical appendices to the Project Report on Treatment of Combined Sewer Overflows by the Dissolved Air Flotation Process. Appendices in this series are:

A. Phase I - Pre-Construction Studies on Quality and Quantity Relationships of Combined Sewage Flows and Receiving Water Studies at Outer Marina Beach

B. Technical Objectives for Field Demonstration of Baker Street Dissolved Air Flotation Facility

C. Treatment of Raw and Dilute Raw Sewage with the Dissolved Air Flotation Process - A Pilot Plant Study

D. Design Factors for Baker Street Dissolved Air Flotation Facility

E. Costs for Dissolved Air Flotation Facilities

F. Characterization of the Receiving Water and Beach Intertidal Zone Environment

G. Performance Evaluation of Baker Street Facility with Raw Sewage

Appendix A is submitted in fulfillment of DPW Order Nos. 80,479 and 84,944 between the City and County of San Francisco and Engineering-Science, Inc., and was supported in part by Grant WPRD-258-01-68 between the Environmental Protection Agency, Water Quality Office, and the City and County of San Francisco, Department of Public Works.

This report, prepared in limited edition for utilization in City and County of San Francisco's Master Plan study for wet-weather control, is under review for approval by the Environmental Protection Agency, Water Quality Office.

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CHAPTER I

INTRODUCTION

Combined sewage flows are the combination of various types of discharges to a sewer system designed to convey both urban wastewaters and storm runoff in a single conduit. The discharges consist of sanitary wastewater, industrial discharges where applicable, and (during wet weather) surface runoff wastewater. Because of the high intensity of the contribution of surface runoff wastewaters, combined sewage flow rates frequently exceed the capacity of the existing dry weather treatment facilities intended primarily for the handling of dry weather flows. Traditionally, for those time intervals during which the capacity of treatment facilities is exceeded, the excess flow has been discharged directly to the receiving water. These combined sewer overflows have been identified as a major short-term source of pollutant materials which contribute to the degradation of the aquatic environment adjacent to many urban areas.

The increased demands of urban populations for a high quality land and water environment have not only generated a need for treatment of combined sewer overflows to improve water quality, but have also delimited land availability in the urban environment for construction of facilities for treatment of combined sewer overflows. Additionally, the need for treatment of combined sewer overflows has placed new demands on available technology for wastewater management systems which can remove pollutant materials deleterious to the quality of receiving waters and require a minimum of land space, maintenance, and operating staff.

The City and County of San Francisco, in its program for upgrading quality levels of wet weather discharges from its combined sewer system, has recognized these needs in the formulation of the Facilities Demonstration Grant Project supporting this investigation. The overall project consists of the design, construction, operation, and evaluation of a demonstration dissolved air flotation facility for the treatment of

combined sewer overflows from the Baker Street Outfall. The demonstration facility will be located in the area of the principal municipal marina on the northern shoreline of the City. The site was selected for the treatment facility because of the ideal size of the contributing drainage basin for demonstration purposes and because of the need for improvement of the quality of receiving waters contiguous to Outer Marina Beach during wet weather. The overall Facilities Demonstration Grant Project has been divided into three phases extending over a three-year period from 1968 to 1971:

Phase I: Pre-construction Studies on Quantity and Quality Relationships of Combined Sewage Flows and Receiving Water Studies at Outer Marina Beach.

Phase II: Design and Construction of Baker Street Stormwater Pollution Control Treatment Facility.

Phase III: Post-construction Studies on Operation and Evaluation of Baker Street Stormwater Pollution Control Facility and Receiving Water Studies at Outer Marina Beach.

This report summarizes the findings of the Phase I study, conducted between November 1968 and April 1970. The Phase II effort was completed in October 1970 (when the treatment facility became operational) and the Phase III studies extend through the period of August 1970 through July 1971.

OBJECTIVES

The general objective of Phase I was to provide background data for the evaluation of the efficacy of the dissolved air flotation process in treating combined sewer overflows. From this will be developed engineering data which can be made available to the large number of communities faced with similar problems. The specific objectives were to:

(1) Characterize pollutionally significant factors in the Baker Street drainage basin, including rainfall, surface runoff, dry weather

flows, and combined sewage flows.

(2) Establish quantitatively the physical, chemical, and biological quality of receiving waters and the physical and chemical quality of the beach intertidal zone at Outer Marina Beach.

(3) Evaluate the influence of other significant pollutional sources in the vicinity of the demonstration facility.

(4) Assess the feasibility of the demonstration treatment process for different characteristic land use areas, through characterization of the time-variant nature and size distribution of particulate materials and floatables in combined sewer overflows.

ORGANIZATION OF PHASE I STUDY

The study was undertaken at the request of the City and County of San Francisco, Department of Public Works, Mr. S. Myron Tatarian, Director. Mr. Robert Levy, City Engineer, served as Project Director; and Mr. Alan O. Friedland, Chief of the Division of Sanitary Engineering, Bureau of Engineering, served as Deputy Project Director. Assisting Mr. Friedland in Phase I studies was Mr. R.T. Cockburn, Bureau of Engineering.

A Project Advisory Board was established to provide overall guidance to the study and to review progress as related to the objectives of the State and Federal agencies represented by board members and their alternates:

Mr. Paul Bonderson, Chief, Division of Water Quality, Water Resources Control Board, State of California.

Alternate: Mr. George Gribkoff

Mr. Fred Dierker, Executive Officer, San Francisco Bay Regional Water Quality Control Board.

Alternate: Mr. Daniel Murphy

Mr. S. Myron Tatarian, Director of Public Works, City and County of San Francisco.

Alternate: Mr. Robert Levy, City Engineer

Mr. Henry Ongerth, Chief, Bureau of Sanitary Engineering, Department of Public Health, State of California.

Alternate: Mr. William Jopling

Mr. Jack Fraser, Chief of Water Projects Branch, Department of Fish and Game, State of California.

Alternate: Mr. Donald Lollock

Dr. Harvey F. Ludwig, Chairman, Engineering-Science, Inc.

The project was conducted by the staff of the Research and Development Laboratory/Berkeley, Engineering-Science, Inc. under the direction of Dr. P.N. Storrs. Dr. T.G. Shea served as Project Manager. Project staff included Drs. J.D. Westfield and G.D. Beers, Messrs. G.O. Hajek, L.P. Kolb, W.G. Zimmerman, J. Bartlett, D. Cobb, and J. Burns, and Mrs. T. Wistrom.

ACKNOWLEDGMENTS

This investigation was funded in part by Facility Demonstration Grant Project No. WPRD-258-01-68 of the Environmental Protection Agency, Water Quality Office.

CHAPTER II

SUMMARY

The findings of the first phase of a three-phase, three-year effort leading to the design, construction, operation, and evaluation of a demonstration dissolved air flotation facility for the treatment of combined sewer overflows are summarized in this report. The dissolved air flotation facility, being developed under the auspices of a Facilities Demonstration Grant Project (Environmental Protection Agency, Water Quality Office), will treat combined sewer overflows bypassed to the Baker Street outfall in San Francisco, which discharges to Central San Francisco Bay at Outer Marina Beach. The general objectives of the Phase I study were to: (1) establish quantity and quality relationships for combined sewer overflows from differing types of land-use areas; and (2) provide reference background information on the environmental quality of receiving waters and the beach intertidal zone at Outer Marina Beach needed for evaluation of the effectiveness of the dissolved air flotation unit for enhancing quality levels in these areas.

DRAINAGE BASIN STUDIES

Quantity and quality relationships for combined sewer overflows were developed by a study of the dry and wet weather wastewater emissions from a total of six drainage basins in San Francisco. Five of the six drainage basins (Baker Street, Mariposa Street, Brotherhood Way, Selby Street, and Laguna Street) have combined sewage systems in which the wet weather discharges consist of sanitary wastewaters, industrial discharges where applicable, and surface runoff wastewaters. The sixth basin is located at the foot of the Vicente Street drainage basin and contains separate storm and sanitary sewer systems. The stormwater flows monitored in this area are believed to contain no sanitary or industrial sewage and the emissions are limited to wet weather runoff. Predominant land uses in the six basins are: single, high value residential (Baker); single, medium value residential (Brotherhood, Selby, and Vicente);

multiple residential (Laguna); and industrial (Mariposa). Dry and wet weather monitoring in two of the six basins (Selby and Laguna) was conducted during an earlier study (1966-1967); the Baker, Mariposa, Brotherhood, and Vicente basins were monitored in the present study. The results of the earlier study were incorporated into the development of quantity and quality relationships for combined sewage flows presented in this report of the present study.

The combined sewer systems of the Baker, Mariposa, Brotherhood, Selby, and Laguna basins are intercepted at or before the points of discharge to the receiving water system, and 100 percent of the dry weather flow is diverted to three sewage treatment plants which have a capacity to treat combined sewage flows up to a total design hydraulic flow of 340 mgd. The interceptor systems are designed to handle the dry weather flow plus the runoff from 0.01 to 0.02 in./hr of rainfall. Flows in excess of this amount are bypassed directly to the Bay and Ocean.

Dry weather monitoring of the combined sewer systems was conducted in the Baker, Mariposa, and Brotherhood basins during this study, and in the Selby and Laguna basins in 1966-1967, to provide data for estimation of the dry weather sewage component of combined sewage flows. Hourly samples were taken and flow measurements made over one or more 24-hr periods in each of the five basins with combined sewer systems. The wet weather monitoring of combined sewage flows consisted of flow rate measurement and sampling for constituent analysis during a total of 20 storm periods in the six drainage basins. Flow determinations were carried out at the Baker, Mariposa, Brotherhood, and Vicente drainage basins using a dye-dilution technique, in which the dye Rhodamine WT was injected at a measured flow rate to the sewer system from 500 to 700 feet upstream from the sampling point; Rhodamine WT was detectable in concentrations as low as 20 µg/l without background interference from particulate or coloring materials in the sewage flows. Samples were withdrawn from the sewer system by a self-priming centrifugal pump system.

Results

Dry Weather Monitoring

The average per capita flow and mass emission coefficients for dry weather flows from the monitored basins were as follows: flow, 106 gcd (gallons per capita per day); COD, 0.353 pcd (pounds per capita per day); BOD, 0.148 pcd; TSS, 0.155 pcd; VSS, 0.125 pcd; floatable materials, 0.0046 pcd; hexane extractable materials (HEM), 0.049 pcd; total nitrogen (TN), 0.026 pcd; ammonia nitrogen, 0.009 pcd; and ortho-phosphate-phosphorus, 0.0054 pcd. These average coefficients are not representative for all the drainage basins of San Francisco. The flow observations made for all systems showed variations typical of urban areas. Flow maxima occurred during morning and evening periods and a principal minimum occurred between 5:00 and 7:00 a.m. for the basins monitored. The diurnal sewage quality variations were also characteristic of urban areas, and no unusual patterns were observed.

The median value of coliform MPN concentrations in dry weather raw sewages (all samples) was 29 x 10^6 MPN/100 ml. A correlation was found to exist between median coliform MPN concentration and sewage strength as defined by the COD characteristic.

Wet Weather Monitoring

The wet weather monitoring effort involved a total of 11 storms in this study in the Baker, Mariposa, Brotherhood, and Vicente basins; nine storms were monitored in the studies at Selby and Laguna basins in 1966-1967. Runoff factors were estimated for each storm by dividing the "due-to-storm" flow (difference between total combined sewage flow over the rainfall period less the expected dry weather flow over the same time period as defined from the dry weather monitoring described above) by the rainfall volume, and are shown in Table II-1. The large storage capacity of the Selby System (12.2 acre-feet) has lowered the runoff factor of that system for storms of short duration. It is unclear why the exceptionally high runoff factors at Baker (114 percent) and Vicente Area I (121 percent) or the low factor at Brotherhood (29.9 percent) were obtained.

TABLE II-1

HYDROLOGIC DATA FOR MONITORED STORMS

Drainage Basin	Date of Storm	Rainfall (in.)	Funoff Factor (%)	Antecedent Dry Period (days)	Runoff Duration (hr)
Baker	4-5 April 1969	0.25	114	1	2
	15 October 1969	0.23	70.1	<1	3
	5 November 1969	0.64	77.8	19	5
Mariposa	27-28 February 1969	0.31	79.8	<1	8
	20 March 1969	0.18	70.9	11	5
	2 April 1969	0.06	58.3	12	1
Brotherhood	14 January 1970	0.30	65.8	<1	4
	15 January 1970	0.42	29.9	<1	4
	23 January 1970	0.02	50.6	<1	3
Vicente (Area 1)	16 February 1970	0.39	121.0	2	5
Vicente (Area 2)	16 February 1970	0.39	72.8	2	5
Selby	6 November 1966	0.98	35.8	50	4
	14-15 November 1966	0.42	59.6	1/2	8
	20 January 1967	3.92	81.3	42	36
	23 January 1967	0.72	84.6	1-1/2	8-1/2
	24 February 1967	0.22	13.7	11	1-1/2
	10 March 1967	1.34	20.2	7	*
	15 March 1967	0.74	34.8	<1	*
Laguna	10 March 1967	1.01	34.6	7	*
	15 March 1967	0.81	47.3	<1	*

NOTE: * Not measured.

With the exception of these values, the average runoff factors for the drainage systems are within the range of values normally expected for the land use types represented by these basins.

The discrepancies in the runoff factors noted above may be due to variations in rainfall patterns during any given storm between the location of the United States Weather Bureau raingauge (downtown San Francisco) and the drainage area. Observations from the United States Weather Bureau station were the primary source of rainfall data in the present study. Preliminary measurements by the City with a series of 13 raingauges distributed across the City have shown that a 20 to 40 percent spatial variation in rainfall occurs typically the same time period in different sectors of the City. For this reason, the City is installing a system of raingauges and flow stage stations linked to a central data processing unit to provide the data needed to develop further insight on the rainfall patterns (and resultant generation of combined sewer overflows that must be controlled) in San Francisco. The analysis of the data being developed in this independent program was beyond the scope of this study.

Other factors that may account for the unexpected values of runoff coefficients are undefined interconnections between drainage basins, and interbasin transfer of surface runoff due to clogged catch basins or sewer laterals. During the fall of 1970, four interconnections were identified and plugged in the Baker Street area and three in the Brotherhood Way area. There is also some question as to the extent of the surface drainage for the Vicente drainage basin which may also include sections of the Great Highway and Ocean Avenue not included in the original calculated area.

Rainfall intensities in the monitored storms listed in Table II-1 varied from 0.01 to 0.80 in./hr, averaging 0.12 in./hr for all observations. This average rainfall initially has been exceeded about 10 percent of the time in the historical rainfall pattern for San Francisco; that is, only storms of higher than average rainfall intensity were selected for monitoring.

An analysis of the time variance of concentration profiles for constituents in individual combined sewage flow events indicated that the occurrence of peak constituent levels was associated with a rapid rate of increase of flow rate in the combined sewer following an increase in rainfall intensity. The implicit indication of this recurrent observation is that these peak concentrations are associated with a rapid increase in the level of scour in the sewer system and of surface wash. The antecedent dry period (dry weather period prior to occurrence of the monitored rainfall) was not observed to be a necessary condition for the occurrence of peak concentrations.

Coliform analyses were conducted on storm runoff samples (Vicente Street) and combined sewage samples (Baker, Mariposa, Brotherhood, Selby, and Laguna drainage basins) for all storms listed in Table II-1. The median of the mean coliform MPN concentrations for the data from each drainage system was 6.2 x 10^6 MPN/100 ml, or 22 percent of the median level for dry weather (raw sewage) flows. The median coliform MPN levels in storm runoff from the Vicente drainage basin were 7 x 10^5 MPN/100 ml (Area 1) and 1.6 x 10^5 MPN/100 ml (Area 2), or five and one percent of the median dry weather flow MPN concentration, respectively. In comparison, the median coliform MPN level in a shoreline monitoring station at Outer Marina Beach (Station No. 25) during wet weather was 1,960 MPN/100 ml, or three orders of magnitude less than the median coliform level for the combined sewages and two orders of magnitude less than observed for storm runoff.

Storm Runoff Mass Emission Equations

In order to establish a capability for predicting the contribution of storm runoff and sewer system scour to combined sewage flows, mass emissions (lb per storm) were calculated on a "due-to-storm" basis individually for all storms for the following constituents: COD; TSS; TN (total nitrogen); OPP (orthophosphate-phosphorus); HEM (hexane extractable materials); and floatable materials. The net mass emission or the "due-to-storm" emission represents that fraction of the mass flow in a combined sewer which exceeds the mass emission attributable to the

dry weather sanitary flow. Attempts to normalize the "due-to-storm" mass emission data into basin-dependent parameters such as lb/acre, lb/acre-inch, lb/mile street, and lb/population density (cap/acre) and to develop deterministic correlations between these parameters and storm runoff were unsuccessful. The random nature of the data precluded reaching this goal directly, and it was necessary to ascertain whether the basic data for each constituent could be treated as a distribution and the distributions examined to ascertain whether one or more data sets existed which could be described in terms of a mean parameter value and a mean storm runoff value for the data distribution. With the latter approach, it was possible to establish a deterministic relationship between the parameter "lb/acre-inch" and runoff for each of the constituents, *i.e.*, the lb/acre-inch of pollutant emissions were found to decrease as runoff increased. This trend indicated that the equation selected for the relationship could be of the form $Y = a/(b+\bar{I})$, where Y has units of lb/acre-inch, $\bar{I}$ = inches of runoff due-to-storm, or of the form $M = a\bar{I}/(b+\bar{I})$, where M is the net mass emission (lb/acre) per storm of $\bar{I}$ inches runoff. The constants a and b in the equation $M = a\bar{I}/(b+\bar{I})$ for each constituent were found to be:

Constituent	a	b
COD	12	0.01
TSS	24	0.001
TN	0.60	0.01
OPP	0.10	0.01
HEM	2.1	0.1
Floatable Materials	0.24	0.01

The storm runoff mass emission equations represent an initial attempt to quantitatively describe the variation of pollutant loads due to storm runoff over a range of runoff conditions. The equations were derived from data representing storms with an average rainfall of

0.12 in./hr; consequently, their applicability elsewhere must include a consideration of the effect of rainfall intensity on storm pollutant emissions on a local basis. The generalized multibasin approach used in this study precluded the development of information for relating mass emissions due to a storm with basin-specific characteristics such as land use, or with antecedent dry period or rainfall intensity. The random nature of the data is strong evidence that the aggregate parameter, M, lb/acre, as related to $\bar{I}$ inches of runoff due-to-storm, can be used uniformly to estimate pollutant emissions from all the basins studied in San Francisco.

STUDIES ON RECEIVING WATERS AND BEACH INTERTIDAL ZONE AT OUTER MARINA BEACH

Three sampling programs (once during dry weather and twice during wet weather) were conducted at Outer Marina Beach to provide background data on:

(1) Surface water and benthic physical and chemical quality, concentrations of coliform MPN and floatable particulates, and benthic biota.

(2) Beach intertidal zone concentrations of floatable particulates in sediments and particle-size distributions of sediments.

Information developed in the three sampling programs was combined with information available from local, State, and Federal sources, including studies done with the Bay-Delta Model of the United States Army Corps of Engineers, to provide a reference description of the Outer Marina Beach study area.

The findings of these specific investigative efforts provide considerable insight to the quality and hydrodynamic characteristics of the receiving waters offshore from Outer Marina Beach, the impact of dry and wet weather on receiving water quality and a correlation between receiving water and beach intertidal zone quality. Observations made with the Bay-Delta Model of the United States Army Corps of Engineers indicate that significantly different circulation patterns exist in the waters 500 feet

or more offshore than in the nearshore area (where the outfall for the dissolved air flotation facility is located). Beyond the 500-ft nearshore zone, there is a general easterly movement of Bay waters on flood tide and westerly movement on ebb tide. Also, the above patterns exist within the nearshore zone, but the westerly water movement breaks down during ebb slackening into a counterclockwise eddy, and during the flood slackening into a clockwise eddy. The effects of these eddies, of which the former appears to be the more significant, is to constrain the exchange of water in the nearshore zone with the main body of moving waters during much of the tidal cycle.

The Bay-Delta Model observations offer the implication, requiring further *in situ* investigation, that eddy formation and dissipation play a significant role in delimiting the movement of Bay waters past the Baker Street outfall dispersion zone. Eddy formation and dissipation are believed, also, to be the causative factors in the continuing deposition of sand on the central and eastern portions of Outer Marina Beach. Additionally, the current patterns during ebb tide transport waters from the southern estuary northerly and westerly into and past the receiving waters contiguous to Outer Marina Beach, transporting simultaneously significant quantities of dilute treatment plant effluents and combined and storm sewage flows into the area of Outer Marina Beach during wet weather.

The most significant variations between dry and wet weather conditions of all the water quality parameters considered are manifest in the nature of the floatable material and coliform MPN parameters. The average floatable particulate concentration in wet weather was 10.5 mg/sq m, or over one order of magnitude greater than the average dry weather concentration of 0.55 mg/sq m. The average dry weather concentration in surface waters was 0.44 mg/sq m westerly of the existing outfall alignment and 0.68 mg/sq m easterly of the alignment. The wet weather levels were 7.8 mg/sq m in the westerly sector and 12.1 mg/sq m in the easterly sector, indicating that levels in waters easterly of the alignment are over 50 percent greater in all seasons than are waters in

the westerly sector. It is noteworthy that there are no sanitary sewage discharges or combined sewer overflows westerly from the Baker Street outfall to Baker's Beach outside of the Golden Gate. The HEM fraction of the floatable particulates increased from 0.01 percent in dry weather to two percent in wet weather. Because of the order of magnitude variation in floatable particulate levels between dry and wet weather, it is evident from the findings of this study that HEM levels varied by three to four orders of magnitude between dry and wet weather in the receiving waters of Outer Marina Beach. In spite of this significant increase, most (≤ 98 percent) of the particulate floatables are of plant or animal rather than of sewage origin.

Median coliform MPN levels varied significantly between dry and wet weather both in the shoreline and offshore sampling stations. The median coliform MPN levels at Outer Marina Beach (Station No. 25) from mid-1966 to December 1968 were 320 MPN/100 ml in dry weather versus 1,960 MPN/100 ml on rainy days (> 0.02 in. rainfall), or a factor of six difference between dry and wet weather median levels. The median coliform MPN levels in the receiving water grid sampled during this study (250 to 1,500 ft offshore) were 140 MPN/100 ml in dry weather and 1,000 MPN/100 ml in wet weather, *i.e.*, a difference of a factor of seven. Thus, a similar level of change in coliform MPN levels for dry and wet weather was observed at both the shoreline and offshore stations. The statistical analysis also indicated that the mean wet weather coliform MPN level at Station No. 25 decreased to mean dry weather levels in less than five dry weather days after a rainy day.

The tidal current stage was also found to be a significant variable affecting the wet weather coliform MPN level at the shoreline sampling station at Outer Marina Beach (Station No. 25). Median coliform MPN levels at flood and high slack stages during wet weather were approximately 1,200/100 ml, or one-third the median levels observed at this station for ebb and low slack stages. The distributions of coliform MPN levels between flood/high slack and ebb/low slack stages were found to be significantly different at 68 percent confidence level, and are evidence of the impact of wet weather wastewater discharges easterly of Outer Marina

Beach on the quality of receiving waters contiguous to Outer Marina Beach.

The beach intertidal studies indicate that a positive trend also exists in changes in HEM levels in the receiving waters and beach intertidal zone between dry and wet weather conditions. The mean specific HEM content of intertidal zone sands varied from 20 mg/kg in dry weather to 97 mg/kg during the April 1969 wet weather survey and 62 mg/kg in the January 1970 wet weather survey. These changes correlate positively with increases of three to four orders of magnitude in the HEM levels in receiving water floatable particulates, and offer strong evidence of the interdependence of receiving water and beach intertidal zone quality in the Study Area.

EVALUATION OF DRY WEATHER AND COMBINED SEWAGE WASTEWATER LOADS

The wastewater loads from a combined sewerage system are comprised of dry weather (perennial) sanitary and industrial discharges, as well as seasonal (wet weather) wastewater emissions, transported to the system in surface runoff or scoured from the system. The pollutional impact of combined sewage flows on receiving waters can be reduced or eliminated by treatment and/or storage facilities located at the bypass structure of the system or at the existing dry weather sewage treatment facilities. The dry weather per capita coefficients and the storm runoff mass emission equations developed in the present study can be used to estimate dry and wet weather wastewater loads on a per-storm, seasonal, or annual basis as a means of gaining insight to the implications of different wastewater management program alternatives.

The coefficients and equations were used to evaluate two questions anticipated to be important in the selection of dry and wet weather wastewater management alternatives:

(1) To develop a per-storm comparison between estimated dry weather and combined sewage pollutant emissions and wet weather receiving water quality, as a basis for evaluating the immediate impact of combined sewage emissions on receiving water quality.

(2) To permit a comparison on an annual basis of the relative magnitude of pollutant emissions from both dry weather and combined sewage flows, assuming various levels of treatment in each case, in order to provide an overall basis for evaluating the mass of pollutants removed as a function of where treatment is provided.

Wastewater Emissions and Receiving Environment Quality

In order to evaluate the first question above, the receiving water quality data developed in the two wet weather and one dry weather surveys were used as reference information, and the dry weather coefficients and due-to-storm equations were used to estimate wastewater emissions on the day of, and for several days preceding, each of the receiving water surveys. The following conditions were considered in this application example:

(1) There is an implication that the quality of the receiving environment at Outer Marina Beach may be related to the magnitude of wastewater emissions to the Bay system during wet weather. For the application example a comparison of dry weather and combined sewage wastewater emissions was developed using the coefficients to estimate the treated dry weather, treated storm runoff, and bypassed (untreated) combined sewage wastewater emissions from the North Point and Southeast drainage districts of the City.

(2) Dry weather wastewater emissions from these districts were estimated on the basis of the population and treatment plant efficiency characteristics reported in Table II-2 for three parameters: TSS, HEM, and floatable materials.

(3) Storm runoff wastewater emissions were estimated with the due-to-storm equations for TSS, HEM, and floatable materials, and an assumed composite runoff factor of 70 percent for the North Point and Southeast districts. It was then assumed that the combined sewage generated by the initial 0.02 in. of rainfall was diverted to the dry weather system and subjected to treatment at the sewage treatment facility before discharge to the receiving system at the same efficiency level as the dry weather flow.

TABLE II-2

APPLICATION EXAMPLE

ESTIMATED DRY WEATHER WASTEWATER EMISSIONS FROM NORTH POINT AND SOUTHEAST DRAINAGE BASINS, SAN FRANCISCO

District	Estimated Population	Land Area	Dry Weather Mass Emission Coefficients (pcd)[1]			Dry Weather Wastewater Emissions (10^3 lb/day)[2]		
			TSS	HEM	Floatable Materials	TSS	HEM	Floatable Materials
North Point	400,000	9,000	0.173	0.040	0.0025	69,200	16,000	1,000
Southeast	175,000	7,100	0.165	0.029	0.0025	28,000	5,100	440
Treated Dry Weather Emissions from Both Basins						48,600	15,800	720

NOTES: [1] Laguna Street coefficients used for North Point Drainage District, and Selby Street coefficients used for Southeast Drainage District (Table V-1).

[2] Treated dry weather emissions based on following removal efficiencies for primary treatment:

TSS: 50%
HEM: 25%
Floatable Materials: 50%

(4) The total wet weather wastewater emissions were estimated as the sum of the treated dry weather emissions, treated storm runoff emissions (from the initial 0.02 in. of rainfall), and bypassed combined sewage emissions.

(5) The rainfall data used in the example were obtained from the station at the Federal Office Building in San Francisco; it is assumed that these rainfall levels also occurred in the North Point and Southeast drainage districts.

A summary of the estimated total emissions of TSS, HEM, and floatable material and the receiving water particulate floatable and coliform MPN levels during the three receiving water surveys is presented in Table II-3. The rainfall averaged 0.30 in./day on the three days preceding the first wet weather receiving water survey (24-25 February 1969) and 0.25 in./day on the three days preceding the second wet weather survey (9-10 January 1970). The dry weather survey was conducted on 26-27 May 1969.

As reported in Table II-3, the estimated total emissions of TSS, HEM, and floatable materials were from two to six times greater during wet weather than during dry weather. Between dry and wet weather conditions the observed particulate floatables in the receiving water increased by one to two orders of magnitude and the surface density of HEM was found to increase by three to four orders of magnitude. The median fecal coliform MPN levels were found to be 10 to 15 times higher, and the median total coliform MPN levels were observed to be seven to 23 times higher during wet weather relative to dry weather conditions. Similarly, the HEM content of beach sediments was found to increase by an average of three to four times between dry and wet weather conditions (Table II-3). It is apparent from the foregoing that a positive correlation exists between the magnitude of wastewater emissions during dry and wet weather (as estimated herein) and the observed receiving environment quality. That is, a 200 to 600 percent increase in estimated wastewater emissions during a rainy season was associated with order-of-magnitude increases in level of receiving water characteristics.

TABLE II-3

APPLICATION EXAMPLE

ESTIMATED DRY AND WET WEATHER WASTEWATER EMISSIONS AND RECEIVING ENVIRONMENT QUALITY

Date	Estimated Total Wastewater Emissions- Dry and Wet Weather[1] (lb/day)				Observed Receiving Environment Quality			
					Particulate Floatables		Median Coliform MPN/100 ml	
	Rainfall (in.)	TSS	HEM	Floatable Materials	mg/sq m	% HEM	Total	Fecal
20 Feb 1969	-	48,600	15,800	720				
21 Feb 1969	0.29	308,000	32,800	3,230				
22 Feb 1969	0.21	307,000	31,800	3,170				
23 Feb 1969	0.40	311,000	34,400	3,360				
24 Feb 1969	0.63	314,000	35,300	3,330	10.5	-	910	360
25 Feb 1969	0.27	308,000	32,500	3,276				
26 May 1969	-	48,600	15,800	720	0.55	<0.01	140	35
27 May 1969	-	48,600	15,800	720				
6 Jan 1970	-	48,600	15,800	720				
7 Jan 1970	0.03	293,000	20,800	2,490				
8 Jan 1970	0.18	301,000	30,400	3,140				
9 Jan 1970	0.57	313,000	35,600	3,330				
10 Jan 1970	-				10.5	2.2	3,200	500

NOTE: [1] Sum of treated dry weather, treated stormwater runoff, and bypassed combined sewage wastewater emissions.

The scope of the present study did not permit the field evaluation of the time required for wet weather receiving environment quality to revert to dry weather conditions following the cessation of rainfall. The observation (reported above) that coliform MPN at Outer Marina Beach decreased from mean wet to dry weather levels in less than five dry weather days indicates that the Bay system has a natural capacity to attenuate and/or disperse pulse inputs of organisms of sewage origin. If the rate of decay of coliform MPN level to dry weather conditions is representative of other parameters affecting the beneficial uses of the receiving water (such as particulate floatables), then the number of days on which water quality will be impaired by wet weather emissions is a function of the discrete time intervals between storm patterns as well as of the time span between the initial and final rainfalls of the season.

Estimated Annual Wastewater Emissions

The annual dry weather and combined sewage emissions were estimated for the Baker Street drainage basin by cumulating estimates of the per-storm combined sewage emissions occurring over a recent historical rainfall pattern and estimates of dry weather wastewater emissions. This application example is not based on an entire annual record of rainfall, but rather on a time period (1 October to 15 December 1969, which represented 21 percent of a year) during which a total of 4.52 inches of rainfall (or 22 percent of normal annual rainfall) was recorded at the Federal Office Building raingauge of the United States Weather Bureau.

It is assumed that the rainfall record observed at the Federal Office Building also occurred throughout the Baker Street basin. Because the time interval is approximately the same portion of a year as is the rainfall in the time interval relative to the total annual rainfall, the conditions calculated for this period were assumed to be representative of conditions on an annual basis. Storms exhibiting intensities in excess of 0.02 in./hr occurred for a total of 56 hours during the total time of 2.5 months, or about three percent of the time. For the assumption that the bypass of combined sewage flow occurs only at or above this rainfall intensity, bypasses would have occurred on an average of three

percent of the time on an annual basis. A runoff factor of 75 percent was used for the Baker Street basin (Table II-1) and runoff pollutant emissions were calculated using the storm runoff mass emission equations. Dry weather flows and mass emissions were calculated for the time interval using coefficients for Baker Street and the Baker Street basin population equivalent of 13,200.

The portion of the combined sewage flow that was diverted to the dry weather system during the time period used in the example was estimated as that resulting from the initial 0.02 in./hr of rainfall. It was assumed that combined sewage flows generated by rainfalls in excess of 0.02 in./hr were bypassed to the receiving system without treatment; in the present example, the latter circumstance occurred three percent of the time.

The untreated mass emissions from dry weather flows, storm runoff, and wet weather bypasses calculated with this protocol are presented on a lb/acre-year basis in Table II-4. The untreated total mass emissions includes 9,620 lb/acre-year of COD and 5,260 lb/acre-year of TSS. About 90 percent of the total flow and COD, over 95 percent of the TN, OPP, and HEM, and over 75 percent of the TSS and floatables in the total annual flow would be derived from the dry weather component. Storm runoff contains, per unit of COD, about 5, 0.8, 0.4, 0.5, and 3 times the TSS, TN, OPP, HEM, and floatables, respectively, found in dry weather flows.

In reference to combined sewage overflows, it is estimated that nine percent of the COD, 26 percent of the TSS, and 16 percent of the floatable emissions generated on an annual basis in the Baker Street basin would be bypassed to the receiving waters (Table II-4). The effect of dry weather flows on the quality of combined sewage overflows is evident from a comparison of the pollutant mass emission of combined sewage overflows and storm runoff. The combined sewage overflows would transport to the receiving water 100 percent more OPP and HEM, 50 to 60 percent more COD and TN, 20 percent more floatables, and eight percent more TSS than would the surface runoff contribution to the bypass.

TABLE II-4

APPLICATION EXAMPLE
COMPARISON OF MASS DISCHARGES
FROM BAKER STREET DRAINAGE BASIN

Constituent	Untreated Mass Emissions (lb/acre-year)				Untreated Mass Emissions (% of total)		
	Dry Weather Flow	Storm Runoff	Total	Combined Sewage Overflow	Dry Weather Flow	Storm Runoff	Combined Sewage Overflow
COD	9,060	560	9,620	830	94	6	9
TSS	4,020	1,240	5,260	1,360	76	24	26
TN	565	28	593	45	95	5	8
OPP	179	4	183	9	98	2	5
HEM	1,750	60	1,810	112	97	3	6
Floatable Materials	56	11	67	11.2	84	16	19
Average Flow (cfs/acre)	0.0157	0.0020	0.0177	0.0025	88	12	15

NOTE: Combined sewage overflow calculated as sum of three percent of dry weather flow and storm runoff discharges.

The combined sewage overflow is estimated to equal about 15 percent, or one-sixth, the dry weather flow. Thus, it is apparent, based on this example, that the combined sewage overflow would contain significantly more HEM, OPP, COD, and TN, than would storm runoff, and that the dry weather contribution of floatable materials and TSS to the combined sewage overflow is much less significant.

An assessment of the effect of primary and secondary waste treatment alternatives, based on the information of this example, on the total annual mass discharges from the Baker Street drainage basin is summarized in Table II-5. Included are alternatives dealing with primary and secondary treatment of dry weather flows, and primary treatment of combined sewage overflows. Several implications about treatment of the waste flows follow from these alternatives:

(1) The principal benefits of primary treatment of the total flow as compared with dry weather flow only would be derived from increased removals of TSS (approximately 30 percent) and floatables (approximately 20 percent), both constituents being associated with the esthetic character of waste discharges. Total flow primary treatment would increase total COD, TN, and HEM removal by about 10 percent over the situation in which the same level of treatment of dry weather flow only would be provided.

(2) Secondary treatment of dry weather flow only would be significantly more effective than total flow primary treatment; from two to three times more COD, TN, OPP, and HEM and about one and one-half times more TSS and floatables would be removed by the former method in comparison with the latter.

(3) The untreated combined sewage overflow component of the total load is similar in magnitude to the fraction of the dry weather flow not removed by secondary treatment of the dry weather flow. About 11 percent of the COD, six percent of the HEM, and 16 percent of the floatables in the total mass emissions remain after secondary treatment of the dry weather flow; in comparison, the combined sewage overflow contains nine percent of the COD, seven percent of the HEM, and 19

TABLE II-5

APPLICATION EXAMPLE

EFFECT OF WASTE TREATMENT ALTERNATIVES ON TOTAL ANNUAL MASS DISCHARGES FROM BAKER STREET DRAINAGE BASIN

Constituent	% Removal By Treatment		Total Annual Untreated Mass Emission (lb/acre-year)	% Reduction in Total Effected By				Untreated Combined Sewage Overflow (% of total flow emissions)
	Primary	Secondary		Primary Treatment Dry Weather Flows	Primary Treatment of Total Flows	Secondary Treatment Dry Weather Flows	Secondary for DWF; Primary for CSO[1]	
COD	35	90	9,620	32	35	84	87	9
TSS	50	95	5,260	37	50	72	85	26
TN	10	20	593	9	10	19	20	8
OPP	5	15	183	5	5	15	15	5
HEM	25	95	1,810	23	25	92	93	6
Floatable Materials	50	90	67	41	50	76	84	19

NOTE: [1] Secondary treatment for dry weather flows and primary treatment for combined sewage overflows.

percent of the floatables. Percentages of suspended solids are noticeably higher, and percentages of total nitrogen and orthophosphate-phosphorus significantly lower, in the combined sewage overflow, relative to what the estimated dry weather emission to the receiving system would be after secondary treatment.

EVALUATION OF COMBINED SEWAGE, STORM SEWAGE, AND RECEIVING WATER QUALITY

Present Objectives

The San Francisco Bay Regional Water Quality Control Board has established the beneficial uses of the Bay receiving waters, contiguous to the Outer Marina Beach at Baker Street, as follows:

(1) Swimming, wading, pleasure boating, marinas, launching ramps, fishing, and shellfishing.

(2) Industrial cooling water.

(3) Fish, shellfish and wildlife propagation and sustenance, and waterfowl and migratory bird habitat and resting.

(4) Navigation channels and port facilities.

(5) Esthetic enjoyment.

In order to protect these benefits, the Regional Board has formulated waste discharge and receiving water quality requirements which are applicable to all combined sewage discharges.

The following requirements are of concern with respect to the quality of combined sewage flow:

(1) All waste discharges shall meet the following quality limits in any grab sample:

(a) Grease, 25 mg/l maximum.

(b) Settleable matter, 1.0 ml/l/hr maximum.

(2) All waste discharges shall meet these quality limits in any representative sample:

(a) Toxicity: survival of test fishes in 96-hr bioassays

of the waste as discharged:

(1) Any sample, 75 percent minimum.

(2) Average of any three or more consecutive samples collected during 21 or more days, 90 percent.

(b) pH, 7.0 minimum and 8.5 maximum.

The following receiving water requirements are of concern:

(1) None of the discharges shall cause unreasonable effects to any of the protected beneficial uses resulting from (a) floating, suspended, or deposited macroscopic particulate matter, oil or grease, in water of the State at any place; (b) bottom deposits at any place; and (c) floatables, color, or turbidity more than 400 ft from the Baker Street outfall.

(2) None of the discharges shall cause bacterial concentrations in waters of the State at any place within one foot of the surface to exceed a median value of 240 MPN coliform per 100 ml, as determined in any five consecutive samples collected at any one station, or any single sample to exceed an MPN coliform concentration of 10,000 MPN/100 ml at any time.

Present Combined and Storm Sewage Quality

The results of the combined and storm sewage monitoring program provide a basis for comparing the observed levels of toxicity, pH, settleable solids, and grease in these streams with the levels specified in the RWQCB requirements. The toxicity bioassay results indicate that 12 of 13 combined sewage samples and two of four storm sewage samples had toxicity levels (96-hr percent survival levels) that were within the quality limits of the requirements. While additional information is needed to indicate conclusively the toxicity characteristics of these streams, it is apparent that the combined and storm sewage flows do not pose a toxicity problem relative to the current RWQCB requirements.

An evaluation of the pH, settleable solids, and grease data for combined and storm sewage flows monitored during the present and 1966-1967 studies indicate the following observations to be appropriate:

(1) Over 50 percent of the pH values observed in the combined sewages and all pH values observed in the storm sewages were outside of RWQCB quality limits (7.0 to 8.5).

(2) Over 80 percent of the settleable solids levels in the combined sewages and 30 percent of the settleable solids levels in the storm sewages were in excess of the RWQCB limit of 1.0 ml/l/hr.

(3) None of the grease levels observed in the storm sewages and 10 to 50 percent of the grease levels observed in the combined sewages were in excess of the RWQCB limit of 25 mg/l.

The present significance of the pH problem identified above is unknown with respect to the impact on receiving water quality. However, it is apparent that the settleable solids and grease concentrations in the combined sewages monitored in the two studies pose significant problems with respect to the RWQCB limits and that storm sewages are a problem area to a lesser extent and only with respect to the settleable solids limit.

Present Receiving Water Quality

The findings of this study indicate that the hydrodynamic regime operative in Central San Francisco Bay results in the formation of longshore currents beyond about 500 ft offshore which move into the Bay system during flood tide and which reverse and move out of the Bay during ebb tide. Observations on the Bay-Delta Model of the United States Army Corps of Engineers indicate that counterclockwise eddies form during ebb slackening and clockwise eddies form during flood slackening in the zone from 500 ft offshore to the shoreline at Outer Marina Beach. No effort could be made to document the extent and duration of these eddies in the field program on this study; however, because the Baker Street outfall discharges to the zone in which the locations of the eddy patterns were indicated to be, there is a need for more detailed study of circulation patterns in the nearshore receiving waters in conjunction with the post-evaluation studies.

While there is, at present, only limited definition of current

patterns in the nearshore zone (0 to 1,000 ft offshore) at Outer Marina Beach, considerable implication exists that the quality of these receiving waters is controlled by upstream waste discharges. The ebb tide transports significant quantities of diluted treatment plant effluents and combined and storm sewage flows from the southern estuary and the Bay past the northeasterly shore of San Francisco toward the ocean. The effect of upstream discharges is apparent from an analysis of coliform MPN levels at Station No. 25 (St. Francis Yacht Club) at incoming and outgoing tidal current stages in wet weather. The data used for the analysis were developed between July 1966 and December 1968 (after chlorination had been implemented at all major Bay discharges). A three-fold difference was observed between mean coliform MPN levels at ebb-low slack tidal current stage (3.4×10^3 MPN/100 ml) and flood-high slack stage (1.2×10^3 MPN/100 ml). Inasmuch as there are no sanitary or combined sewage discharges between the Baker Street Outfall and Baker's Beach (outside the Golden Gate Bridge), the three-fold difference in coliform MPN levels is attributable to the transport of coliforms from waste discharges located easterly of the Baker Street Outfall.

Another perspective for the coliform MPN problem in the receiving waters and shoreline at Outer Marina Beach can be seen from the comparison of coliform MPN distributions in waste discharges and receiving waters shown in Figure II-1. The median of mean coliform MPN concentrations in the dry weather flows from five basins (Baker, Mariposa, Brotherhood, Selby, and Laguna) was 29×10^6 MPN/100 ml. The median of mean coliform MPN concentrations in combined sewage flows from these basins was 6.2×10^6 MPN/100 ml, or 22 percent of the mean level for dry weather flows. The mean coliform MPN concentration for all wet weather samples at Station No. 25 was 19.5×10^2 MPN/100 ml, indicating that the receiving water mean coliform MPN levels are about 3,000-fold less during wet weather than the median coliform MPN level in combined sewage flows.

The mean dry weather coliform MPN concentration at Station No. 25 was 3.5×10^2 MPN/100 ml, or about 80,000 times less than the mean dry weather flow level of 29×10^6 MPN/100 ml. The mean dry weather coliform MPN level at Station No. 25 (3.5×10^2 MPN/100 ml) is nearly 50 percent

greater than the median level specified by the Regional Board for waters of Central San Francisco Bay (Reference VII-1). Consequently, the receiving waters at Outer Marina Beach are subject to water quality degradation which can be associated with adjacent and upstream discharges to the Bay system, and the mean coliform MPN level at Station No. 25 (mid-1966 to 1968) is significantly in excess of present receiving water requirements. Also, based on the dry weather coliform MPN data distribution in Figure II-1, there is a two percent probability that the dry weather coliform MPN level at Station No. 25 will exceed the maximum level of 10,000 MPN/100 ml stated in the requirements.

The other area of concern with respect to existing receiving water quality is the nature and magnitude of floatable materials on the water surface under wet and dry weather conditions. During wet weather conditions, the levels of floatable materials in receiving waters (average, 10.5 mg/sq m) are one to two orders of magnitude greater than detected under dry weather conditions (average, 0.55 mg/sq m). Moreover, the HEM fraction (relating to the quantities of grease and related products in the floatables) averaged two percent of the particulate floatables under wet weather conditions. Consequently, upstream treated and untreated waste discharges have a significant impact on the floatables levels (oil and grease fraction thereof) in the receiving waters of the Outer Marina Beach. The increased levels of floatables in the receiving waters under wet weather conditions are paralleled by a factor of two increase in the HEM content of the surface sand in the littoral zone.

IMPLICATIONS OF RECEIVING WATER EVALUATION

The foremost findings of the receiving water evaluation are that there exists positive interrelationships at Outer Marina Beach between or among:

(1) Receiving water and beach intertidal zone quality.

(2) Receiving water quality and tidal current stage, with a deterioration in water quality occurring on ebb and low slack tidal current stages.

(3) Receiving water quality and the weather, with a marked deterioration in water quality occurring during wet weather.

The combined sewage overflows generated in the Baker Street drainage basin represented about three percent (on a five-year storm basis) of the total combined sewage overflow (on a flow rate basis) from all bypasses between Baker Street and Fourth Street South.

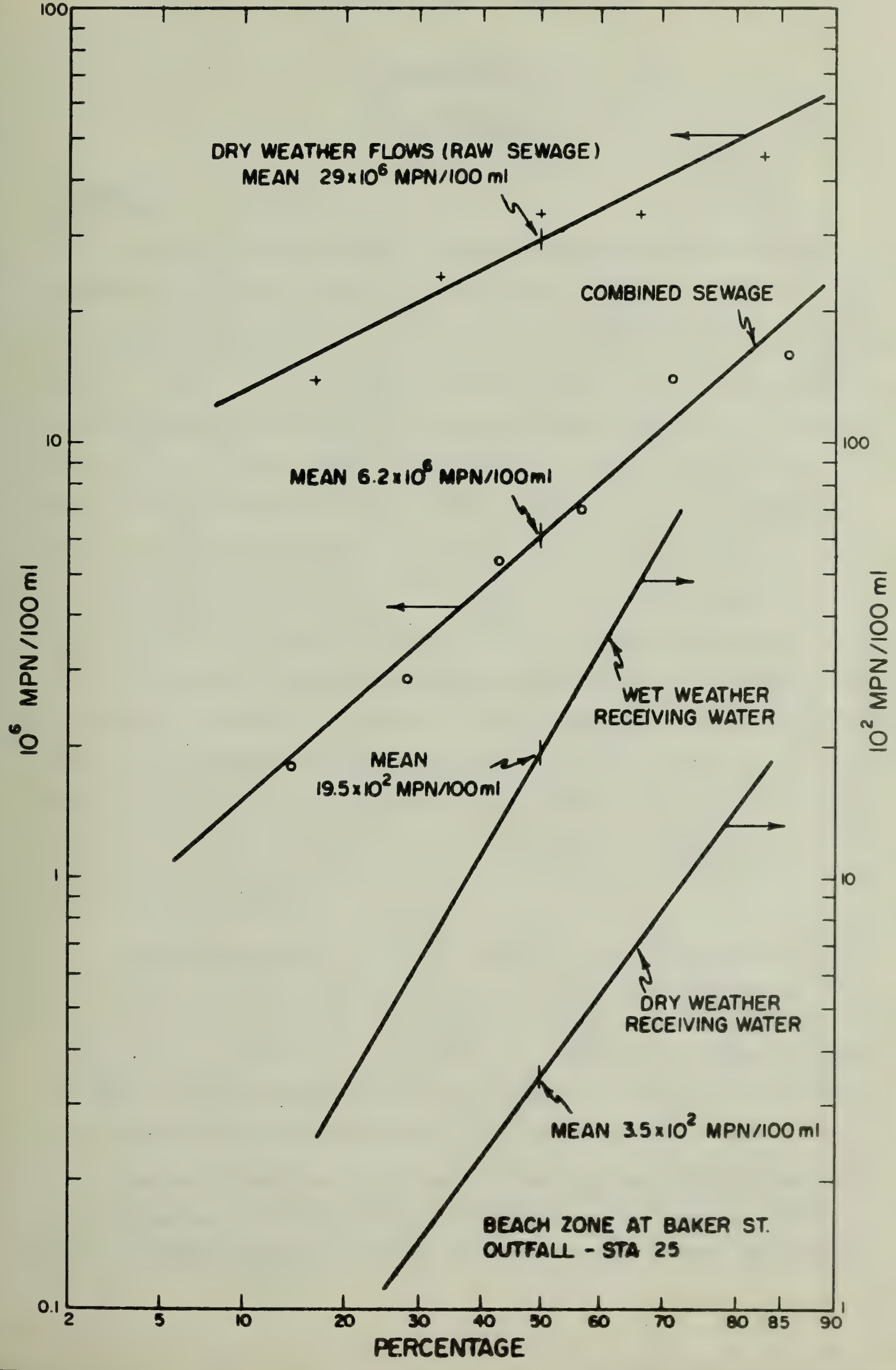
The implications of these findings with respect to current wastewater management planning in the City of San Francisco are two-fold:

(1) It does not appear the demonstration dissolved air flotation facility at Outer Marina Beach will effect ***per se*** a major improvement in wet weather receiving water quality in that area.

(2) It does not appear that receiving water quality in the area west of Pier 45 can be improved by managing combined sewage overflows westerly of this point prior to, and independent of, effective control of overflows and treated effluent discharges easterly thereof. The findings of the present study offer preliminary evidence, requiring additional substantiation, that receiving water quality west of Pier 45 is dependent on the magnitude of waste discharges easterly of Pier 45.

FIGURE II -1

COMPARISON OF COLIFORM MPN LEVELS IN WASTE STREAMS AND RECEIVING WATERS



CHAPTER III

STUDY RATIONALE

APPROACH

The basic premise on which the study was developed was that because of the importance of combined sewer flows as sources of materials which deteriorate receiving water quality under wet weather conditions, a need exists to consider and evaluate the potential for treating these streams. The premise of the pre-construction study is that relationships exist between the character of combined sewer overflows and the characteristics of the drainage area from which the flows originate. In addition to a documentation of these relationships, there exists a need for reference data on the dry and wet weather quality of the contiguous receiving waters and beach intertidal zone prior to construction of the dissolved air flotation facility at the Baker Street site. Subsequent to completion of this facility, the post-construction study will be directed to determining the capability of the treatment facility to provide effluents at a quality level necessary to protect the beneficial uses of the contiguous receiving waters. The efficacy of the treatment facility to improve receiving water and beach intertidal zone quality can be considered only insofar as the treatment facility can remove pollutant materials associated with presently adverse aspects of receiving water quality.

The approach used for the pre-construction study was necessarily directed, in areas where pertinent information was lacking, to an evaluation of fundamental information to illuminate the problem. The approach is illustrated in Figure III-1. Each of the elements shown in this diagram represents an area of inquiry from which information was developed and made available for a subsequent activity.

The basic considerations used in the program approach were the total program objectives and the technical objectives for Phase I. Total program objectives relate to providing background information

necessary for evaluation of the flotation facility for treatment of combined sewage flows, including information required to evaluate the performance capabilities of the flotation facility relative to water quality objectives. The technical objectives are concerned with the quantity and quality characterization of combined sewer overflows and the relationships between these and drainage area characteristics.

The third element in the approach, documentation of problem areas to be considered, requires an awareness of the uses of the land environment as related to the quality of surface runoff and the beneficial uses of the marine environment subjected to the effects of combined sewer overflows. These uses, or their manifestations, include:

(1) Land
    (a) Land use and zoning.
    (b) Land maintenance practice.
    (c) Sewer system operation, performance, and maintenance.
    (d) Air pollution contribution to land pollution.
(2) Receiving water and littoral zone.
    (a) Physiography.
    (b) Tidal and wind-induced circulation.
    (c) Physical, chemical, and biological character of water column, character of benthos, and physical character of beach intertidal zone.
    (d) Accumulative and mass transfer phenomena.

Available information on the significance of the above factors as developed in previous studies by Federal, State, and local agencies was used to identify major study priorities. Based on an analysis of information from these sources (discussed in subsequent chapters), it was possible to:

(1) Select three drainage areas in San Francisco for monitoring of combined sewer overflows; these basins, representing light industrial, multiple/single high value residential, and multiple/single low value residential, complemented the heavy industrial and single/multiple medium value residential areas investigated in the 1966-67 studies by the City and County of San Francisco, Department of Public Works.

(2) Establish a framework for carrying out the receiving water surveys which included: nearshore surveys in a square area approximately 3,000 feet on an edge just seaward from Outer Marina Beach (Chapter IV) to provide reference characterization of effects of the Baker Street outfall on receiving water quality; and beach intertidal zone surveys to provide reference data on the presence of hexane extractable materials on the beach.

The next step in the approach was to document the nature and sources of combined sewage flows. Combined sewage flows can be defined as surge or pulse inputs of surface runoff waters superimposed on or commingled with sanitary and industrial sewage flows. The pulse input of storm waters can generate energy waves in the sewerage system which can be dissipated by generation of shear and drag forces, causing scour of in-sewer deposits, flushing and scouring of retention basins, and mixing, all of which can alter the character of the sewage flow. The pulse input of storm waters of different densities (due to temperature differences) can result in the longitudinal stratification of flows in sewers. As a result, the following types of behavior have been observed under varying circumstances in sewerage systems:

(1) Damping of pulse storm water inputs to the extent that the hydraulic capacity of the dry weather system can accept fully the combined sewage flow.

(2) Generation of "plugs" of sanitary sewage followed by stratified storm water-sanitary sewage flows or by "mixed" storm water-sanitary sewage flows.

(3) Segregation of the combined sewage flow into heterogeneous fractions, in which, *e.g.*, certain fractions contain higher concentrations

of oil and grease or suspended solids than other fractions; the result of system-induced segregation at an overflow structure is that the overflowing portion may contain significantly different concentrations of pollutants than does the portion directed to the dry weather sewer system.

An evaluation of the above factors in each sewer system to be monitored and a consideration of the land characteristics of the source drainage areas were prerequisite to developing a capacity for predicting the behavior of combined sewer systems.

An identification of the temporal and spatial effects of combined sewage flows on the receiving environment was a parallel step to the above evaluations (Figure III-1). Emphasis in this study was placed solely on characterizing the receiving waters contiguous to Outer Marina Beach, which are a part of the Central Bay sector of the San Francisco Bay system. According to the recent Bay-Delta study (Reference III-1) about 600 mgd of treated and untreated municipal and industrial wastewaters are discharged to the San Francisco Bay system in embayments tributary to Central Bay. The dry weather sewage flow in the Baker Street sewer averages less than 2 mgd. In a recent summary of combined sewer overflows along the San Francisco shoreline between Baker Street and China Basin (Reference III-2), the estimated peak flow during a five-year storm from all the overflows was 4,340 mgd, of which 137 mgd (or three percent) was attributed to the Baker Street system. Thus, the effects of the Baker Street system can be identified only in the perspective that this discharge represents a small fraction of the total inventory of wastewaters discharged to receiving waters contiguous to Outer Marina Beach during wet weather conditions.

Tidal and wind-induced circulation patterns in the San Francisco Bay system create a pattern of complex interchanges in the system. Tide phase differences between the northern and southern estuaries of the Bay system effect an undefined degree of transfer of waters from the northern to the southern estuary before the waters leave the system to the ocean. In the daily mixed tidal cycle characteristic of San Francisco Bay, the direction of tidal currents is reversed twice per cycle in the receiving

waters contiguous to Outer Marina Beach. Thus, because of the mixing patterns in the Bay system and the municipal and industrial wastewater discharges to the embayments tributary to Central Bay, it was necessary in the receiving water studies to select and sample for those quality parameters attributable to combined sewage flows from Baker Street in a time reference which would minimize sampling the effects of other discharges in the area. As described in Appendix A, this was done by identifying the tidal current stage and locations at which the receiving waters adjacent to Baker Street could be sampled with minimal expected interference from upstream wastewater discharges.

The foregoing inquiry was carried out to maximize problem definition and identification of data requirements. A compilation and evaluation of existing information developed in this inquiry was used to establish the base of available data. A comparison of this base with information needed to document combined sewage flows and receiving water quality, as discussed above, resulted in identification of the information gaps to be filled in the various aspects of the field program discussed below. As indicated in Figure III-1, the data evaluation step has been viewed as an iterative loop with additional data requirements evolving as the technical program progressed. Specific additional data requirements in this study arose primarily as a result of the evolving standards and objectives of the local water quality regulatory agency. The final step in the study approach, documentation of study findings relative to study objectives, is embodied in this report.

TECHNICAL PROGRAM

The approach to the study discussed in the foregoing section places a major emphasis on the preparatory work done in developing a meaningful technical program. The technical program which evolved from this approach is shown in Figure III-2, and was initiated with a background consideration of drainage area, combined sewage flow, and receiving water characteristics. These work items were implemented over the course of the pre-evaluation study, during which a total of 11 combined sewage flows

and two surface runoff events were monitored and three receiving water surveys were conducted. The results developed in each of these work areas were used to identify and compare the magnitude of wastewater and receiving water characteristics with applicable local receiving water quality objectives and, in the case of the combined sewage flows, for development of predictor relationships between the characteristics of the overflow, rainfall quantities, and, insofar as possible, the drainage area characteristics. Information gained in documentation of factors affecting the quality of the receiving water and beach intertidal zone was used with the predictor relationships for combined sewage flows to assess the impact of untreated combined sewage flow levels on the receiving environment.

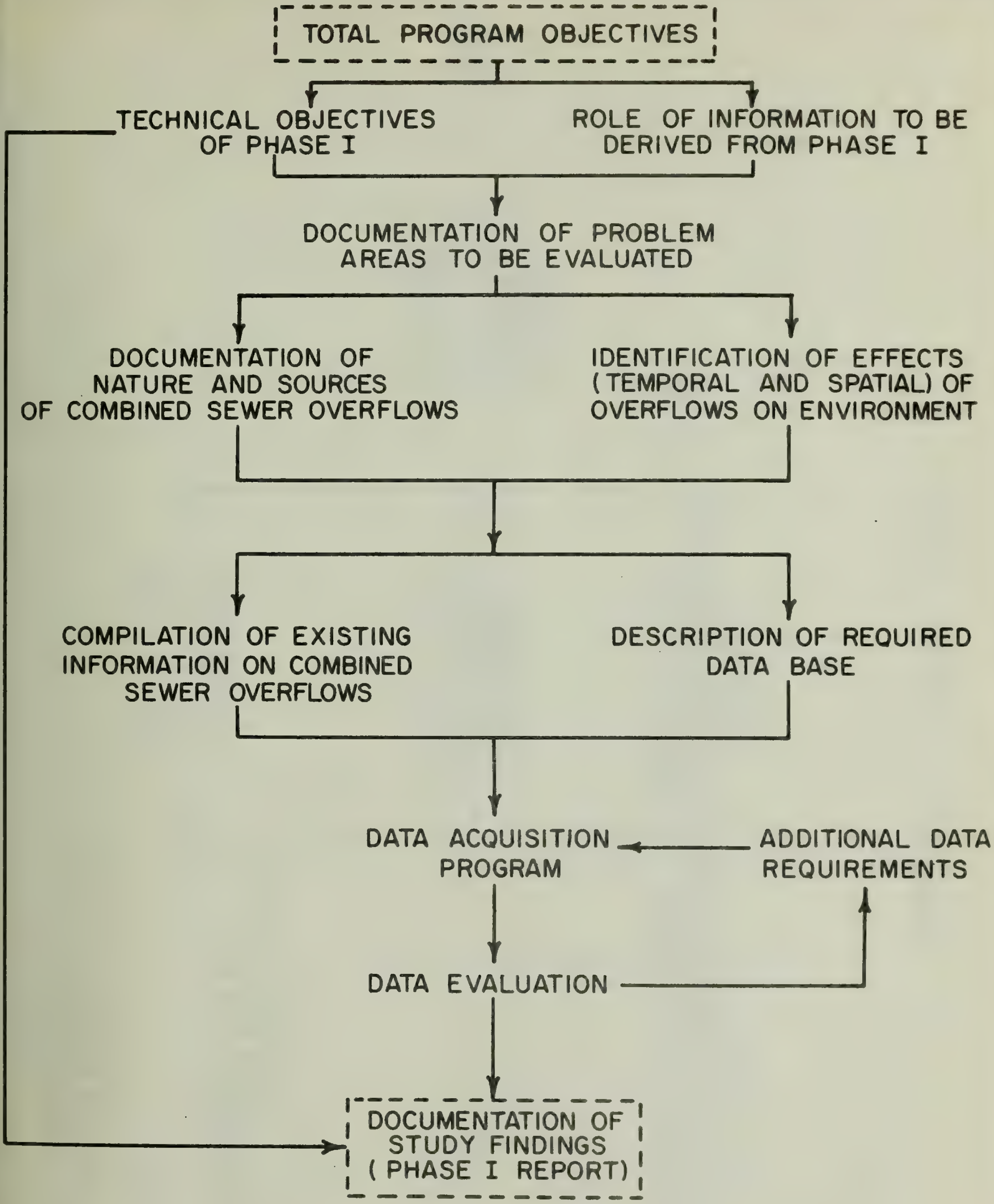
The findings of the Phase I study will serve as a basic information source for the Phase III (post-construction) studies. The technical program of the post-construction studies will be oriented to documenting and modeling the operating capabilities of the dissolved air flotation process and to monitoring process stream and receiving water quality changes effected by its operation. Documentation of the behavior of the dissolved air flotation process entails development of information on the fundamental physical and chemical mechanisms functional in the process, from which it is possible to define the operating programs at the facility necessary to define process behavior. With a definition of process behavior, it will be possible to model process performance under the range of loading conditions which the variable quantity and quality of overflows at Baker Street will impose on the treatment facility. The above effort, coupled with a post-construction characterization of receiving water and beach intertidal zone quality in the waters contiguous to Outer Marina Beach, will permit the development and use of tools for predicting on a broad basis the potential roles of the dissolved air flotation process in the master plan of the City and County of San Francisco for overall wastewater management.

CHAPTER III - LIST OF REFERENCES

III-1 *"San Francisco Bay-Delta Water Quality Control Program"*, Final Report to the State of California by Kaiser Engineers Consortium, June 1969.

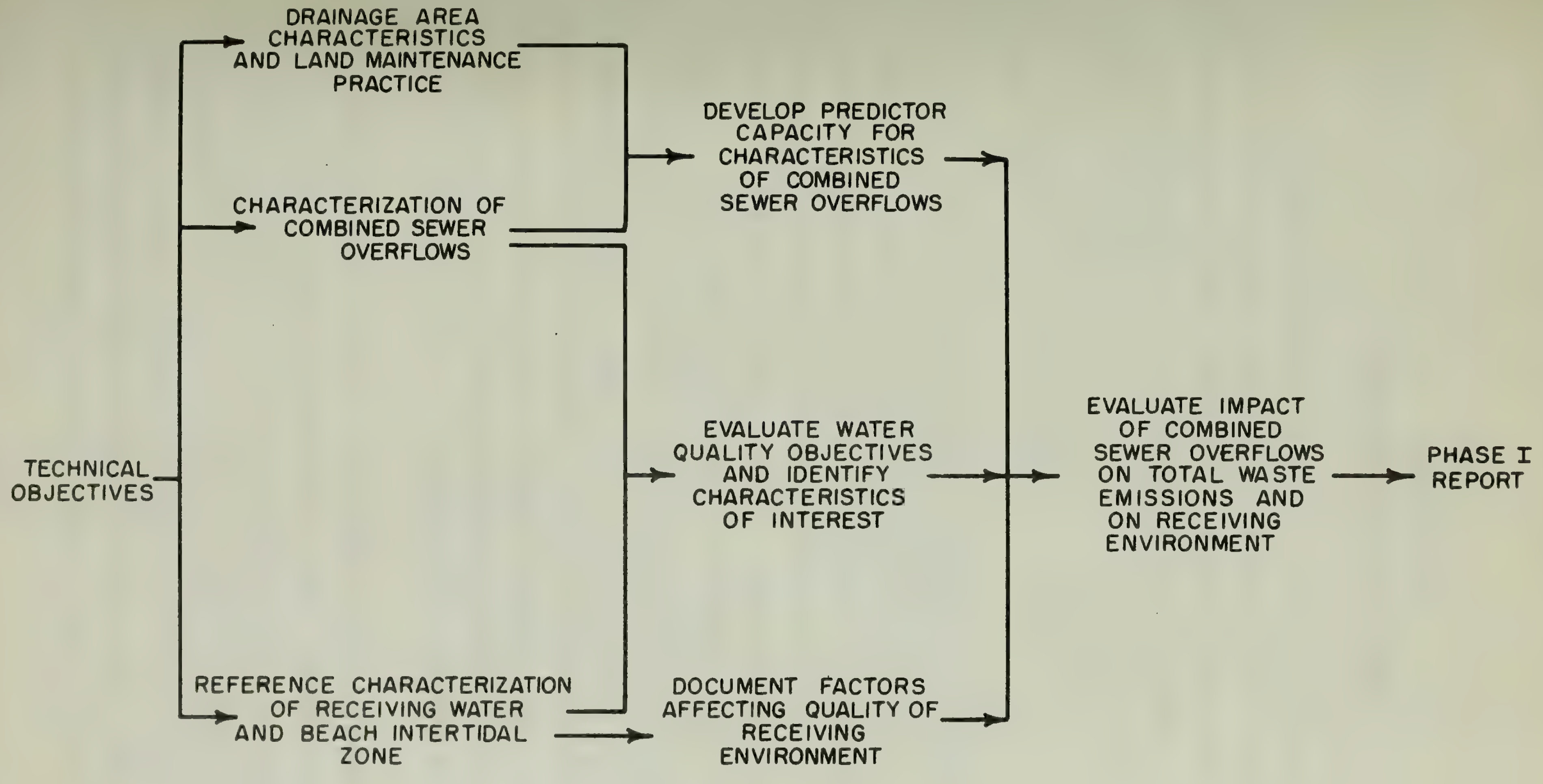
III-2 *"Prescribing Requirements as to the Nature of Waste Discharge by the City and County of San Francisco From Wet Weather Diversion Structures in its North Point Sewerage Zone"*, California Regional Water Quality Control Board, San Francisco Bay Region, Resolution dated 29 January 1970.

FIGURE III-1


TOTAL PROGRAM OBJECTIVES
TECHNICAL OBJECTIVES OF PHASE I
ROLE OF INFORMATION TO BE DERIVED FROM PHASE I
DOCUMENTATION OF PROBLEM AREAS TO BE EVALUATED
DOCUMENTATION OF NATURE AND SOURCES OF COMBINED SEWER OVERFLOWS
IDENTIFICATION OF EFFECTS (TEMPORAL AND SPATIAL) OF OVERFLOWS ON ENVIRONMENT
COMPILATION OF EXISTING INFORMATION ON COMBINED SEWER OVERFLOWS
DESCRIPTION OF REQUIRED DATA BASE
DATA ACQUISITION PROGRAM
ADDITIONAL DATA REQUIREMENTS
DATA EVALUATION
DOCUMENTATION OF STUDY FINDINGS (PHASE I REPORT)

APPROACH TO PHASE I (PRECONSTRUCTION) STUDIES

FIGURE III - 2


TECHNICAL OBJECTIVES
DRAINAGE AREA CHARACTERISTICS AND LAND MAINTENANCE PRACTICE
CHARACTERIZATION OF COMBINED SEWER OVERFLOWS
REFERENCE CHARACTERIZATION OF RECEIVING WATER AND BEACH INTERTIDAL ZONE
DEVELOP PREDICTOR CAPACITY FOR CHARACTERISTICS OF COMBINED SEWER OVERFLOWS
EVALUATE WATER QUALITY OBJECTIVES AND IDENTIFY CHARACTERISTICS OF INTEREST
DOCUMENT FACTORS AFFECTING QUALITY OF RECEIVING ENVIRONMENT
EVALUATE IMPACT OF COMBINED SEWER OVERFLOWS ON TOTAL WASTE EMISSIONS AND ON RECEIVING ENVIRONMENT
PHASE I REPORT

TECHNICAL PROGRAM - PHASE I

CHAPTER IV

DESCRIPTION OF DRAINAGE AREAS

The first comprehensive study for the overall sewerage of the City of San Francisco was undertaken in the 1890's, and construction of a planned system of main sewers and interceptors began about 1910. At that time the need for sewage treatment was not anticipated, and a system of combined sewers was considered to be the most reasonable method for the conveyance of sanitary wastes, industrial discharges, and storm runoff. The discharge points were located at convenient points along the entire coastal periphery of San Francisco.

As a result, the conditions of the Bay and beach areas rapidly deteriorated, and the City initiated engineering studies for waste treatment in 1935. Since that time San Francisco has constructed interceptor sewers which collect all of the dry weather flow. Primary treatment is presently carried out at three locations and after chlorination the effluent from these plants is discharged to the receiving waters. The treatment facilities and sewerage systems have been designed to handle runoff quantities equivalent to up to 0.02 inch of rain per hour, which is equivalent to about twice the normal dry weather flow (the design interceptor ratio is 3:1) but amounts to approximately two percent of the design hydraulic capacity of the storm drain system. Thus, under conditions of heavy runoff, combined sewage flows up to about three times the dry weather flows are routed to the treatment facility, and excess flows are bypassed and discharged to the receiving waters.

The City of San Francisco is divided into three main drainage districts for purposes of sewerage and sewage treatment. Because essentially the entire system is sewered with combined sewers, these districts also define the main watershed areas for storm runoff. The Richmond-Sunset District lies on the west side of San Francisco and comprises a largely residential area of 9,500 acres. The North Point District encompasses 9,000 acres in the northeastern corner of San Francisco and includes the entire downtown section as well as much of the

industrial park located south of the Bay Bridge Skyway. The Southeast District covers approximately 7,100 acres of residential and industrial land. Detailed study was given to four drainage basins located in these districts; these drainage basins (identified by a principal street in the basin) are listed below and are shown in Figure IV-1:

(1) Baker Street (North Point District).

(2) Brotherhood Way and a portion of Vicente Street (Richmond-Sunset District).

(3) Mariposa Street (Southeast District).

The characteristics of combined sewage flows were studied previously in the Selby Street basin (Southeast District) and Laguna Street basin (North Point District) in 1966-1967 (Reference IV-1). Because of the definitive base of information on combined sewage flows in these basins developed in the 1966-1967 study, an evaluation of land use character as well as the nature of combined sewage flows from these areas has been included in this study.

LAND USE AND QUALITY CHARACTERISTICS OF DRAINAGE BASINS

Description profiles based on land use and quality descriptions were developed for each of the six drainage basins. The profiles were developed using available topographic and land use information for San Francisco, most of which was provided by the San Francisco Department of City Planning (Reference IV-2 and IV-3). As backup information, site visits were made to each basin and interviews were held with City personnel whose work related to solid waste management and street and sewer maintenance programs in the basins.

The standard land use categories utilized by the San Francisco Department of City Planning and used in this study are: residential, commercial, industrial, utility and institutional (public or private), recreational, other public, and vacant. Each drainage basin was classified according to the percentage of land utilized for the above purposes and according to population characteristics.

A summary of land use, topographic character, and demography for each basin is given in Table IV-I and discussed below.

Baker Street

The Baker Street urban drainage basin shown in Figure IV-2 borders the southeastern corner of the Presidio Military Reservation with the easterly boundary running along Broderick and Divisadero Streets and the southerly boundary along Clay Street. This area is the only source of wastewaters to the combined sewer system except for sanitary wastes from the Presidio. The Presidio has a separate storm water system which does not connect with the Baker Street combined sewer system. The basin encloses an area of 168 acres with a population estimated to be 13,000 people, including 5,800 persons in the Presidio. The population density in the area which has combined sewerage (outside the Presidio) is 44 persons per acre. Over 80 percent of the land use is for residential purposes. Commercial use of land is estimated to be eight percent with the remaining land being vacant, or belonging to governmental agencies.

The basin is divided topographically into two different sections with different land use characteristics. The southerly section between Pacific and Clay Streets is totally residential with a significant amount of trees and grass; the housing is mostly middle to high income, single family dwellings. The streets are well maintained with almost every block having one or more litter boxes. The streets and gutters contain a minimum amount of litter, mostly grass, deciduous tree leaves and pine needles, and little or no paper or garbage-type material.

The northeasterly section below Pacific Street has some commercial activity centered on and below Lombard Street. The streets surrounding the commercial area are generally more littered with paper than other sections of the basin. This area has several centerally located dumpster-type litter containers which are routinely emptied.

Mariposa Street

The Mariposa Street basin (Figure IV-3) borders the San Francisco Bay on the east, and drains an area as far south as 25th Street, as far

TABLE IV-1

LAND USE AND DEMOGRAPHIC CHARACTER OF BAKER, MARIPOSA, BROTHERHOOD, VICENTE, LAGUNA, AND SELBY DRAINAGE BASINS

Characteristics	Baker	Mariposa	Brotherhood	Vicente (A1/A2)*	Laguna	Selby
Population	13,200	4,500	5,100	0/0	25,300	81,000
Area (acres)	168	233	180	16/21	375	3,400
Pop. Density (pop/acre)	44	20.2	28.1	25[c]	67.5	24
Land Use:						
% Residential	80	29	77	100/80	62	77
% Commercial	8	0	6	0/15	16	2
% Industrial	0	36	-	0/0	6	6
% Other	12	14[a]	11[b]	0/5	16	15[a]
Streets:						
Total length (miles)	8.75	8.45	11.6	1.32/1.64	17.2	136
Land Slope Distr.						
% Land <2 % slope	18.1	36.7	0	0/0	11.4	10.0
% Land 2.5 % slope	9.9	22.2	25.4	100/100	32.2	14.0
% Land 5-10 % slope	33.7	4.4	18.9	-	21.5	34.6
% Land 10-15 % slope	24.7	29.4	31.7	0/0	20.8	18.1
% Land 15-20 % slope	6.5	0	21.3	0/0	14.1	8.6
% Land >20 % slope	7.1	7.3	2.7	0/0	0	14.7
Estimated No. of Catchbasins	140	145	114	12/15[c]	250[c]	2,300[c]

NOTES: * A1/A2 = Area 1 (North Sector)/Area 2 (South Sector).

[a] Vacant

[b] Government

[c] Estimated

west as Carolina Street, and as far north as 16th Street. This basin has a population estimated to be 4,500 persons residing on an area of 223 acres. This population density of the basin is 20.2 persons/acre, reflecting the low residential land use. Only 29 percent of the land is used for residential purposes, while industrial use amounts to over 36 percent. Approximately 14 percent of the land is vacant with the balance used for commerce, utility, recreation, or governmental agencies.

The residential area, though low-middle class, is well kept, and several dumpster-type trash containers are distributed throughout this sector of the basin. The commercial-industrial area consists primarily of light industry devoted to materials and product handling. Large amounts of loose paper and cardboard were observed in the vicinity of 22nd and Iowa Streets. This area is a central point for sorting and storing used paper prior to shipment to pulp stock processing plants. In other sections of the commercial-industrial area, a noticeable amount of small pieces of wood, metal, and glass were observed in the streets. While this material is unsightly due to its bulk and size, it probably would not be transported in any great quantity to the sewers during a storm.

Brotherhood Way

The Brotherhood Way (Ingleside) basin (Figure IV-4) is defined on the south by the County boundary line, by Ralston Street on the west, by Shields Street on the north, and by Orizaba and Capital Avenues on the east. The area of the basin is 180 acres and its population is 5,100 people. The population density is 28.1 persons/acre. Approximately 77 percent of the land use is attributed to residential use with another 11 percent belonging to governmental agencies and the balance to commerce and other uses. The portion of the basin northerly of the Southern Freeway is steeply sloped and almost entirely residential. The streets and gutters were observed to contain little paper, organic litter, or other materials which would be wasted into the sewers during a rain storm.

Vicente Street

The Vicente Street basin shown in Figure IV-5 is a composite of two

small areas northeasterly of the intersection of Sloat Boulevard and Great Highway, both of which have separate storm sewer systems. The drainage basin is believed to include some of the playground area of Fleishhacker Zoo south of Sloat Boulevard; drainage from this area may contain some sanitary flows during wet weather due to overflows from the playground drainage system. The estimated population density of the entire basin is 25 persons/acre.

Area 1 contains 16 acres and is located in the northerly half of the basin. Area 1 has a totally residential land use; and the streets and gutters contain little visible litter. The residences are mostly two story single family dwellings with less than 50 percent of the residential lot devoted to garden cover.

Area 2 is 21 acres in extent and the land use is about 80 percent residential, 15 percent commercial, and 5 percent open land. This section borders the zoo and the area southerly of Sloat Boulevard is used by visitors to the zoo. Some noticeable paper litter was observed in gutters in the commercial area but in general the area appeared to be well maintained.

Areas 1 and 2 of the Vicente Street basin were selected solely for characterization of storm water runoff.

Laguna Street

The Laguna Street basin (Figure IV-6) contains an area of 375 acres generally bordered on the west by Laguna Street, on the north by Bay Street, on the east by Hyde Street and Jones Street, and on the south by Clay Street. With a population density estimated to be 67.5 persons/acre, the population of this basin is about 25,300 persons. Residential use of land amounts to about 62 percent, commercial use about 16 percent, industrial use about six percent, and the remaining land area is used for recreation or governmental purposes.

This basin is adjacent to areas of high visitor interest and is subjected to a large daily transient population. A substantial amount

of paper-based litter is deposited daily in the commercial section of this area. On-street nonmetered parking is permitted along much of the 17.2 miles of street in the basin and parking spaces are occupied a great portion of both the day and night hours, even in sections distant from commercial areas. Street cleaning is restricted by parking. Visual observations of the catch basins during an extended dry weather period indicated that a substantial amount of materials was accumulated in these sumps during dry weather.

Selby Street

The Selby Street basin, shown in Figure IV-7, comprises approximately 48 percent of the Southeast Sewerage District. The land area of this basin is 3,400 acres and the basin is represented by a variety of land use types. Land use surveys show that six percent of the area is industrial, two percent commercial, 15 percent vacant, and 77 percent residential. The total basin population is estimated to be 81,000 with a population density of 24 persons per acre. A large portion of the streets are open for nonmetered parking but the parking spaces are rarely utilized to capacity. The streets and gutters contain a low level of litter and most of the streets are not heavily traveled. The lower portion of the basin (on the Bay side of Third Street) has some very poorly maintained unpaved streets and in this area both solid material and pooled liquid wastes (oil, etc.) were evident.

HYDROLOGY

General Information

The United States Weather Bureau has three official gauging stations in the vicinity: the Richmond-Sunset Water Pollution Control Plant in Golden Gate Park, the Federal Office Building Station located downtown, and the International Airport located about 10 miles south of downtown San Francisco. Annual rainfall data reported by the official stations for the periods 1960 and 1962-1966 are presented in Table IV-2. The average annual rainfalls during the 1960-1966 period were 18.44

TABLE IV-2

ANNUAL RAINFALL DATA FROM OFFICIAL GAUGING STATIONS IN OR NEAR SAN FRANCISCO (1960, 1962 to 1966)

Station	Federal Office Building	Richmond-Sunset	International Airport
Years of Record	117	8	39
Annual Rainfall (inches)			
1966	16.45	17.53	15.98
1965	19.86	21.94	21.22
1964	17.73	16.89	17.54
1963	18.78	21.00	19.89
1962	19.99	23.24	24.25
1960	17.82	17.80	16.90
Average of Above	18.44	19.73	19.30
Long-Term Mean	20.78	-	18.69

inches at the Federal Office Building, 19.73 inches at the Richmond-Sunset Station, and 19.30 inches at International Airport. Thus, the annual rainfall totals varied within a seven percent range at the three stations located on easterly, westerly, and southerly extremities of the City. Based on the information developed at these three stations, it had been assumed by the City in the past that essentially uniform patterns of rainfall occurred across the City.

During the 1969-70 winter season the Bureau of Engineering installed a network of 13 recording rainfall gauges within the City at locations shown in Figure IV-8. An analysis of the data, developed to date from these gauges, has indicated that on a per-storm basis there exists significant spatial and temporal variations in the rainfall patterns over the City. The nature of these variations is exemplified by the data from the 13 raingauges for the period of 18 to 21 December 1969 reported in Table IV-3. The rainfall quantities observed at the different locations varied in the range of ± 40 percent of the average for all stations for the total storm period. The City is now installing (January 1971) a remote raingauge and sewer stage monitoring system linked to a central data processor, and data to be obtained from this system will be used to further confirm the significance of temporal and spatial rainfall variations as a factor of prime importance in the development of combined sewage overflow management systems.

The Bureau of Engineering has analyzed the historical rainfall patterns and runoff characteristics of each of the aforementioned drainage basins using data from the raingauge of the Federal Office Building. The estimated peak discharge for five-year storms at the points of diversion (as developed in the Bureau of Engineering) are:

(1) Baker Street (diversion at Marina Blvd.): 212 cfs.

(2) Mariposa Street (diversion at pump station): 300 cfs.

(3) Brotherhood Way (diversion at St. Charles Street extended): 212 cfs.

(4) Vicente Street (Area I): 19 cfs.

TABLE IV-3

RAINFALL PATTERN OVER THE CITY OF SAN FRANCISCO

(18 to 21 December 1969)

Raingauge Station No.	Rainfall in Total Storm (inches)	Rainfall on Peak Day[a] (inches)	Rainfall in Peak Hour[b] (inches)
901	3.89	2.49	0.75
902	3.98	2.30	0.55
903	3.29	1.50	0.24
904	2.44	1.36	0.00
905	3.63	2.03	0.44
906	3.84	2.41	0.66
907	4.91	2.91	0.75
908	2.91	1.56	0.60
910	3.71	2.27	0.66
911	3.44	1.83	0.62
914	3.15	2.07	0.45
917	3.39	2.29	0.40
918	2.99	2.10	0.58
Average of all Stations	3.50	2.08	0.52

NOTES: [a] 20 December 1969.

[b] 0400 hours, 20 December 1969.

See Figure IV-8 for locations of raingauges in San Francisco.

(5) Vicente Street (Area 2): 23 cfs.

(6) Selby Street (diversion at Islais Creek): 2,700 cfs.

(7) Laguna Street (diversion at North Point Street): 512 cfs.

Baker Street Drainage Basin

The Bureau of Engineering and a consultant to the City have completed a statistical evaluation of 62 years of rainfall data, and from this base, have provided a preliminary evaluation of the number and extent of operations to be expected at the Baker Street facility. It was assumed in their evaluation that a return line exists from the facility to the dry weather sewer having a capacity of 0.02 in./hr (1.40 mgd, assuming a runoff coefficient of 65 percent), a situation which only approximates the case and which makes any predictions of operating duration or extent less than actual by an unknown amount. The results of the statistical analysis indicate that the following probabilistic relationships exist for combined sewage overflows at the Baker Street treatment facility.

(1) At least 12 of the average of 38 rainstorms per year would exceed 0.02 in./hr and would overflow to the flotation facility.

(2) For the 24 mgd design capacity of the facility, and a season of normal rainfall, a normal seasonal total of six inches of rainfall (or 17.7 million gallons at a runoff coefficient of 0.65) would be treated at the facility and one inch of rainfall (3 million gallons) would be bypassed around the plant without treatment.

(3) In a normal season the design capacity of the facility (24 mgd) will be exceeded for only about two hours per year, and 12 mgd will be exceeded for about 20 hours.

(4) A total of 3.06 inches of rainfall or more would bypass the facility with a return frequency of five years and the minimum facility bypass in 62 years would be 4.35 inches of rainfall. These rainfall levels are equivalent to nine million gallons of annual bypass at a five-year frequency and a maximum annual bypass of 12.6 million gallons, respectively.

SEWERAGE AND DIVERSION SYSTEMS FOR DRAINAGE BASINS

The combined sewerage system in San Francisco has evolved over a half century period after 1910, and system capacity considerations over this time span have resulted in the interconnection of many of the systems of adjacent basins at upstream points as well as at points of interception on the periphery of the City. In 1970 steps were taken to eliminate a number of the interconnections throughout the system. Engineering considerations have also resulted in the use of a diversity of structures for directing wet weather flow to outfall structures, adjacent basins, pump stations, and treatment facilities. Consequently, the diversion structures for each of the six drainage basins considered in this and the 1966-1967 studies are different and unique, and the potential behavior of each of these systems during wet weather is considered individually.

Baker Street

Dry weather and combined sewage flows from the Baker Street drainage basin are collected and transported to a diversion structure located at Marina Boulevard and Baker Street, at which point flow is intercepted and transported to the Marina Pumping Station from which it is pumped to the North Point Sewage Treatment Plant. The diversion structure was constructed in a 5-ft diameter sewer and consists of a side-flow weir designed to prevent the incursion of Bay water into the dry weather system and to direct dry weather flows into the 21-in. diameter sewer in Marina Boulevard. During wet weather conditions (unknown rainfall intensities), flows from the Baker and adjacent drainage basins exceed the capacity of the Marina Pump Station, resulting in the overflow of a major portion of combined sewage flow from the Baker drainage basin. The new Baker Street outfall structure terminates at a point about 250 ft offshore at Outer Marina Beach.

A description of the procedures used in sampling the sewerage system are presented in Appendix A and the major sewer sizes and lengths in the Baker Street drainage basin are described in Appendix B (Table B-1).

Mariposa Street

Dry weather and combined sewage flows from the Mariposa Street drainage basin are collected and transported to a diversion structure at the Mariposa Street Pump Station, from which flow is pumped to the Southeast Sewage Treatment Plant. The diversion structure is located just downstream from a sewer sump draining to the sump pump and consists of an accessible double-barrelled sill equipped with tide gates and emptying during wet weather into Central Basin. The pump station continues in operation during wet weather conditions to the extent that sewerage system capacity downstream is available; otherwise operation is stopped, and the total combined sewage flow is diverted to Central Basin.

The sizes and lengths of the major sewers in the Mariposa Street drainage basin are reported in Table C-l of Appendix C.

Brotherhood Way

The Brotherhood Way diversion structure is located at Brotherhood Way and Saint Charles Street (extended). The inaccessible structure consists of a dry weather flow dropout conduit to the sewerage system tributary to the Richmond-Sunset Sewage Treatment Plant, and a wet weather overflow weir to a conduit leading ultimately to the Lake Merced outfall systems. Because the Brotherhood Way drainage basin is at an extreme upstream sector of the Richmond-Sunset Drainage District, it is unknown what fraction of the combined sewage flow from this sector is diverted directly to the Pacific Ocean receiving waters under wet weather conditions. However, it is estimated (Reference IV-l) that in the Lake Merced area only five percent of the storm water presently flows north toward the treatment plant during a five-year storm.

A description of sizes and lengths of the major sewers in the Brotherhood Way drainage basin is given in Table D-l of Appendix D.

Vicente Street

The separate storm sewerage systems of Areas l and 2 empty into the Vicente Street combined sewerage system. The diversion structure is

located at 45th Avenue and Vicente Street, and consists of an 18-inch side flow weir on the outside of a 90° bend in the 6 ft-6 in. trunk sewer. The outfall terminates in a rectangular structure with tide gates and bar racks. Discharge is onto the beach about 75 ft from the surf.

Table E-1 of Appendix E contains a description of the sewer sizes and lengths in the storm sewerage system of Areas 1 and 2.

Selby Street and Laguna Street

The Selby Street and Laguna Street sewerage systems have been described in the final report for the 1966-1967 studies (Reference IV-1) and are not included herein. Tables F-1 (Appendix F) and G-1 (Appendix G) summarize data on sizes and lengths of the major sewers in the Selby and Laguna drainage basins, respectively. It is estimated (Reference IV-1) that greater than 95 percent of the combined sewage flow in the Selby basin during a five-year storm will spill directly to Islais Creek.

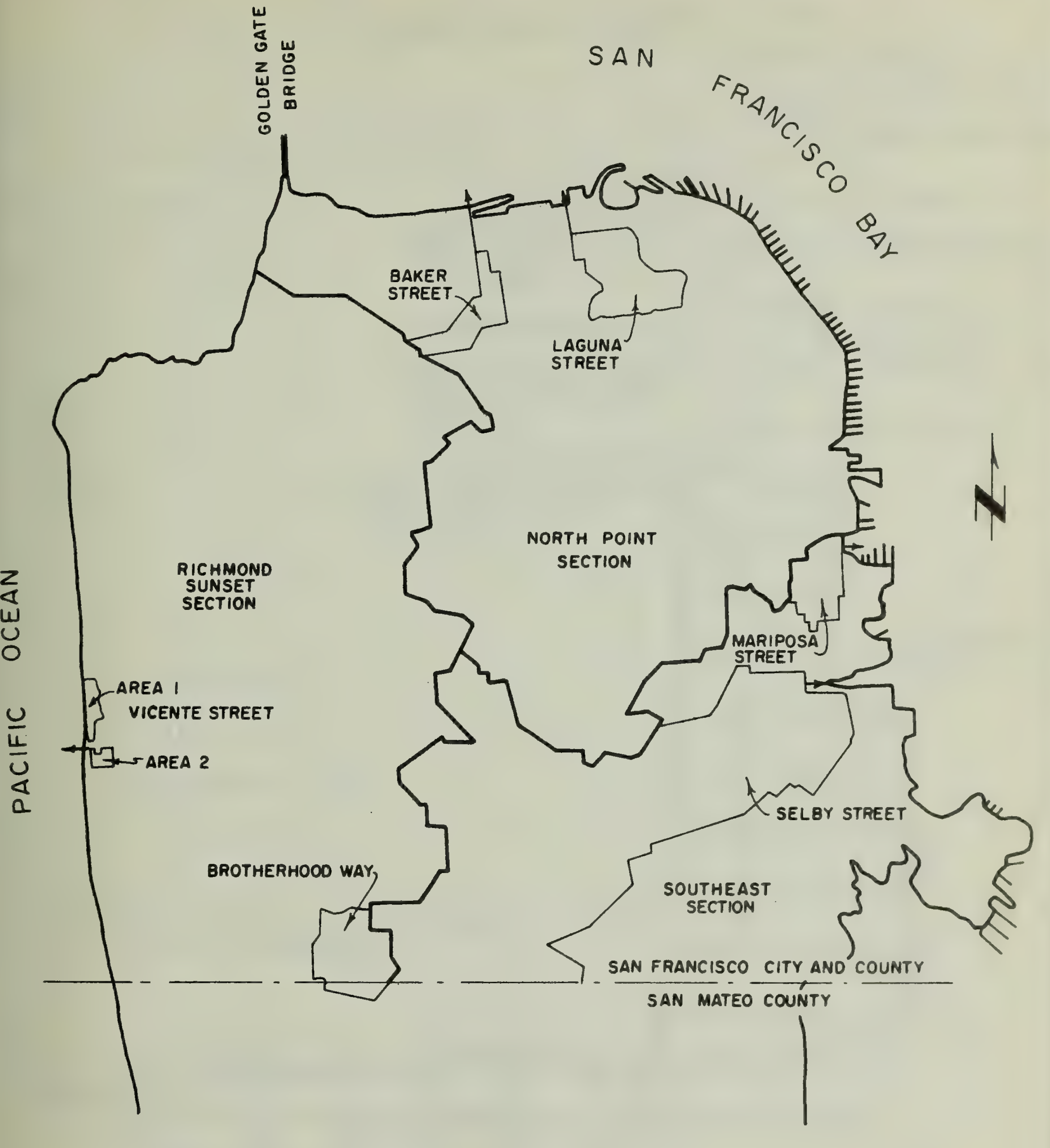
CHAPTER IV - LIST OF REFERENCES

IV-1 *"Characterization and Treatment of Combined Sewer Overflows"*, report to City and County of San Francisco, by Engineering-Science, Inc., November 1967.

IV-2 *"San Francisco Land Use Survey, 1947-1948 and 1961-1964"*, Department of City Planning, City and County of San Francisco, 1964.

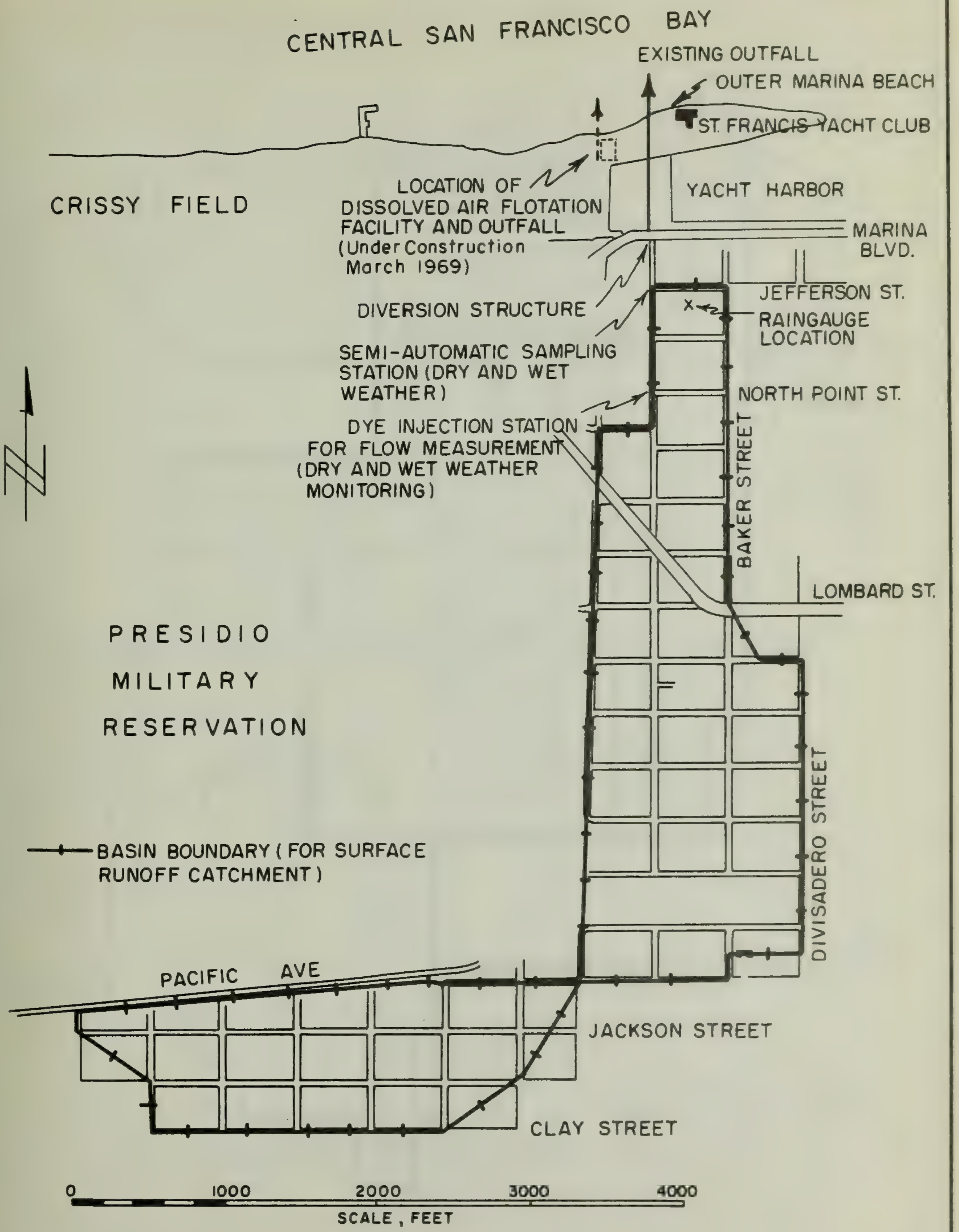
IV-3 *"Annual Report of City and County of San Francisco,"* Department of Public Works, 1968.

FIGURE IV-1

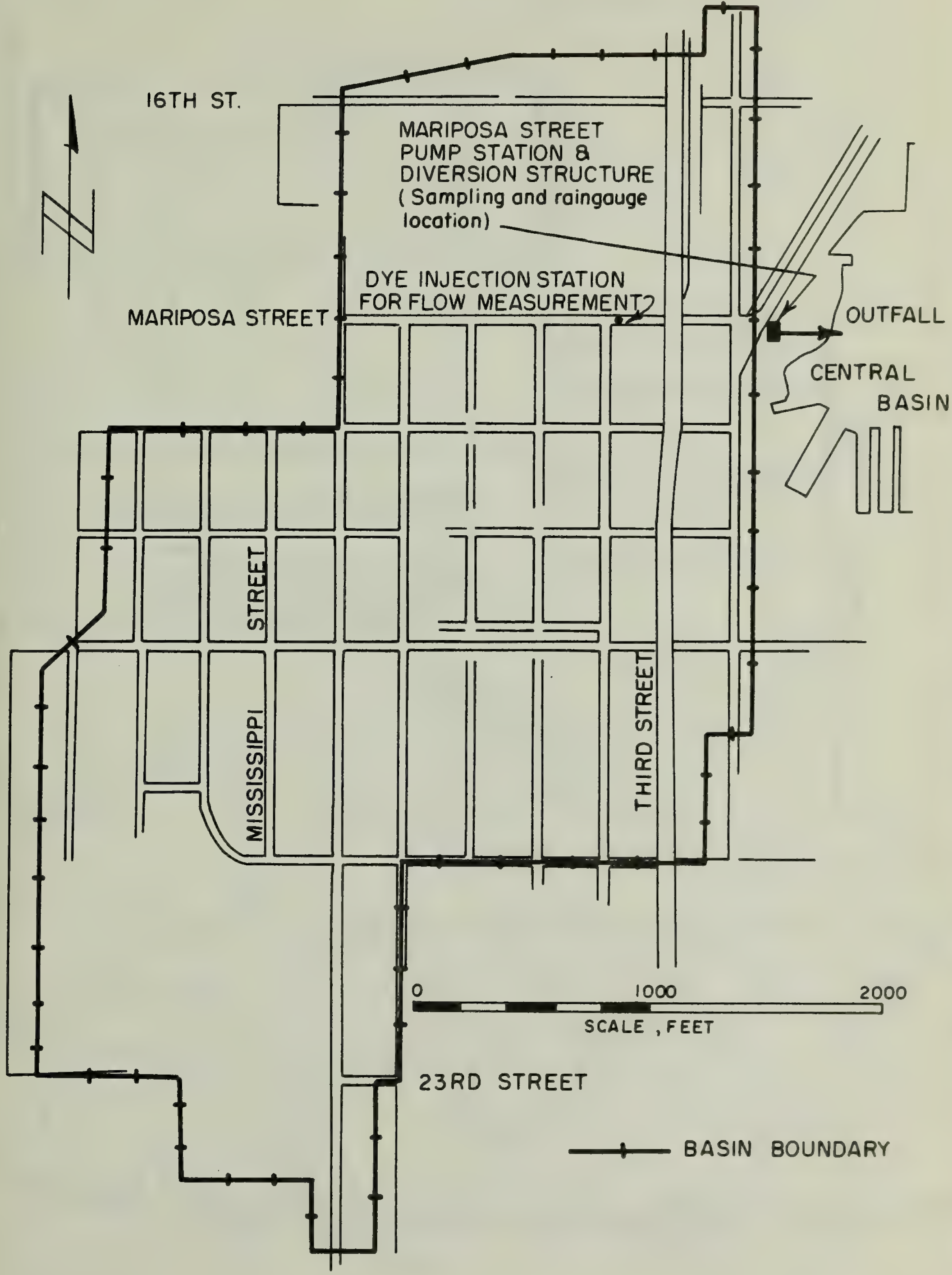


SEWERAGE DISTRICTS AND
STUDY DRAINAGE BASINS
SAN FRANCISCO, CALIFORNIA

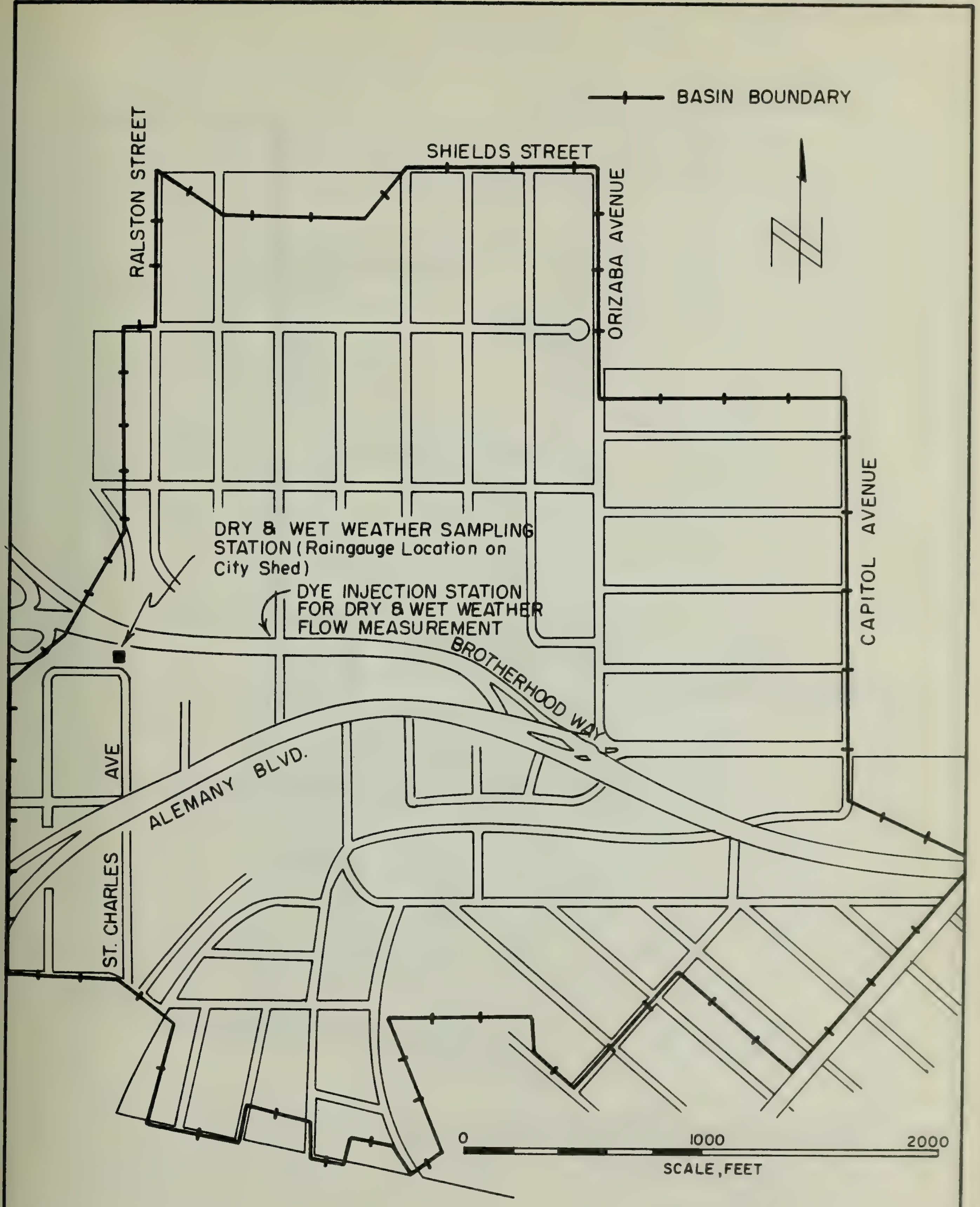
ENGINEERING-SCIENCE, INC.


CENTRAL SAN FRANCISCO BAY
EXISTING OUTFALL
OUTER MARINA BEACH
ST. FRANCIS YACHT CLUB
YACHT HARBOR
CRISSY FIELD
LOCATION OF DISSOLVED AIR FLOTATION FACILITY AND OUTFALL (Under Construction March 1969)
MARINA BLVD.
JEFFERSON ST.
RAINGAUGE LOCATION
DIVERSION STRUCTURE
SEMI-AUTOMATIC SAMPLING STATION (DRY AND WET WEATHER)
NORTH POINT ST.
DYE INJECTION STATION FOR FLOW MEASUREMENT (DRY AND WET WEATHER MONITORING)
BAKER STREET
LOMBARD ST.
PRESIDIO MILITARY RESERVATION
DIVISADERO STREET
BASIN BOUNDARY (FOR SURFACE RUNOFF CATCHMENT)
PACIFIC AVE
JACKSON STREET
CLAY STREET
0
1000
2000
3000
4000
SCALE, FEET

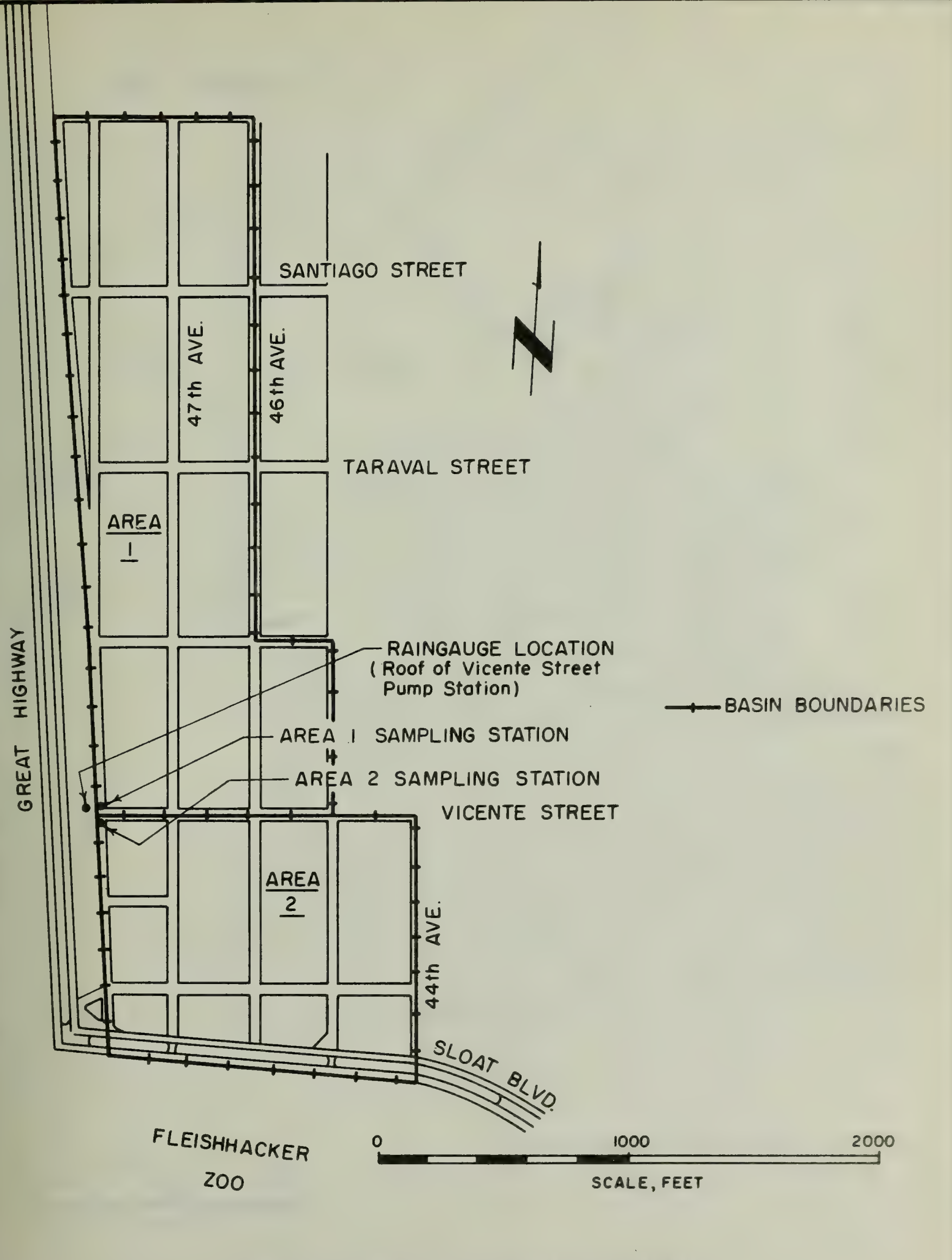
BAKER STREET DRAINAGE BASIN
1969 - 1970 STUDY



MARIPOSA STREET DRAINAGE BASIN
1969 - 1970 STUDY

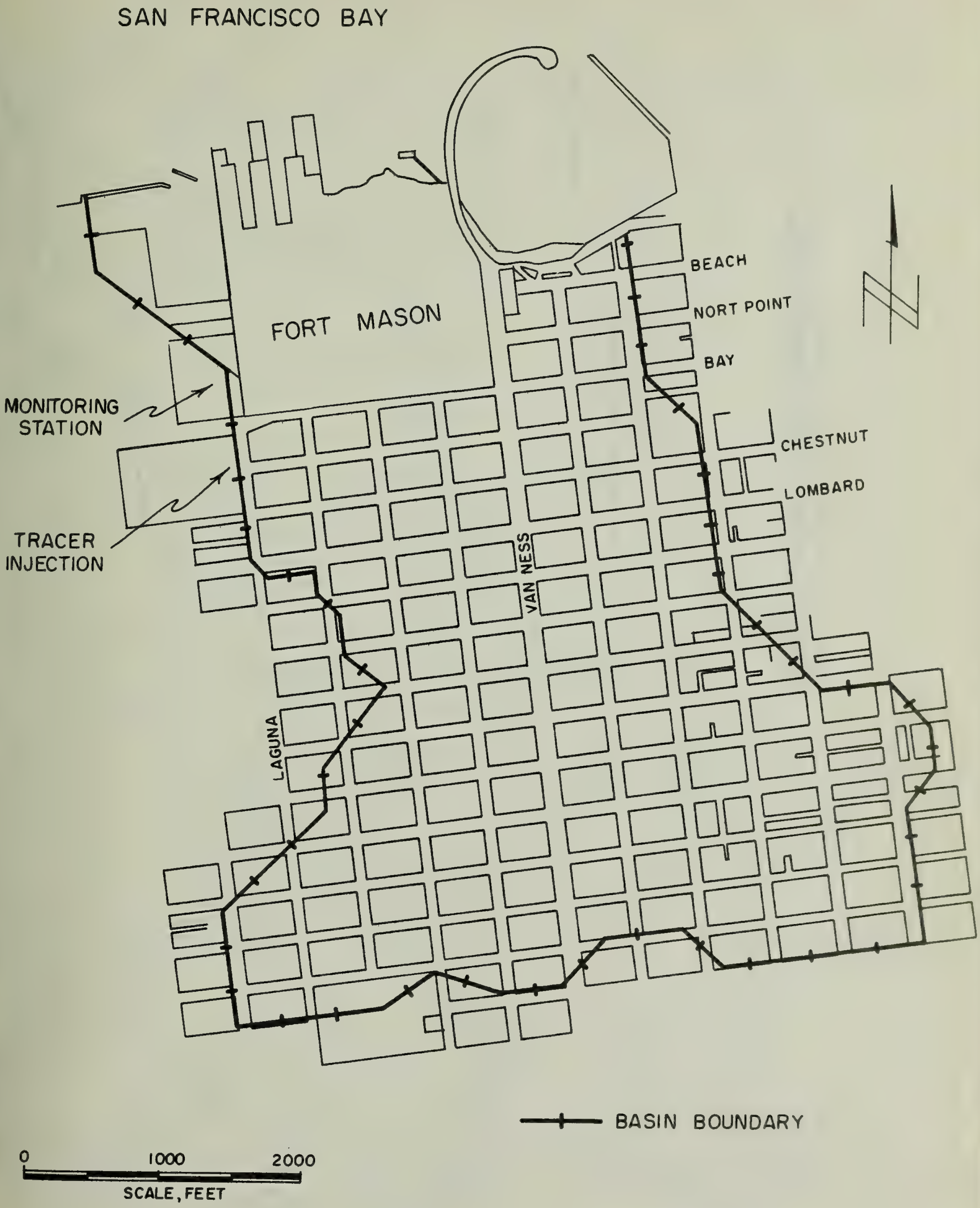


BROTHERHOOD WAY DRAINAGE BASIN
1969-1970 STUDY



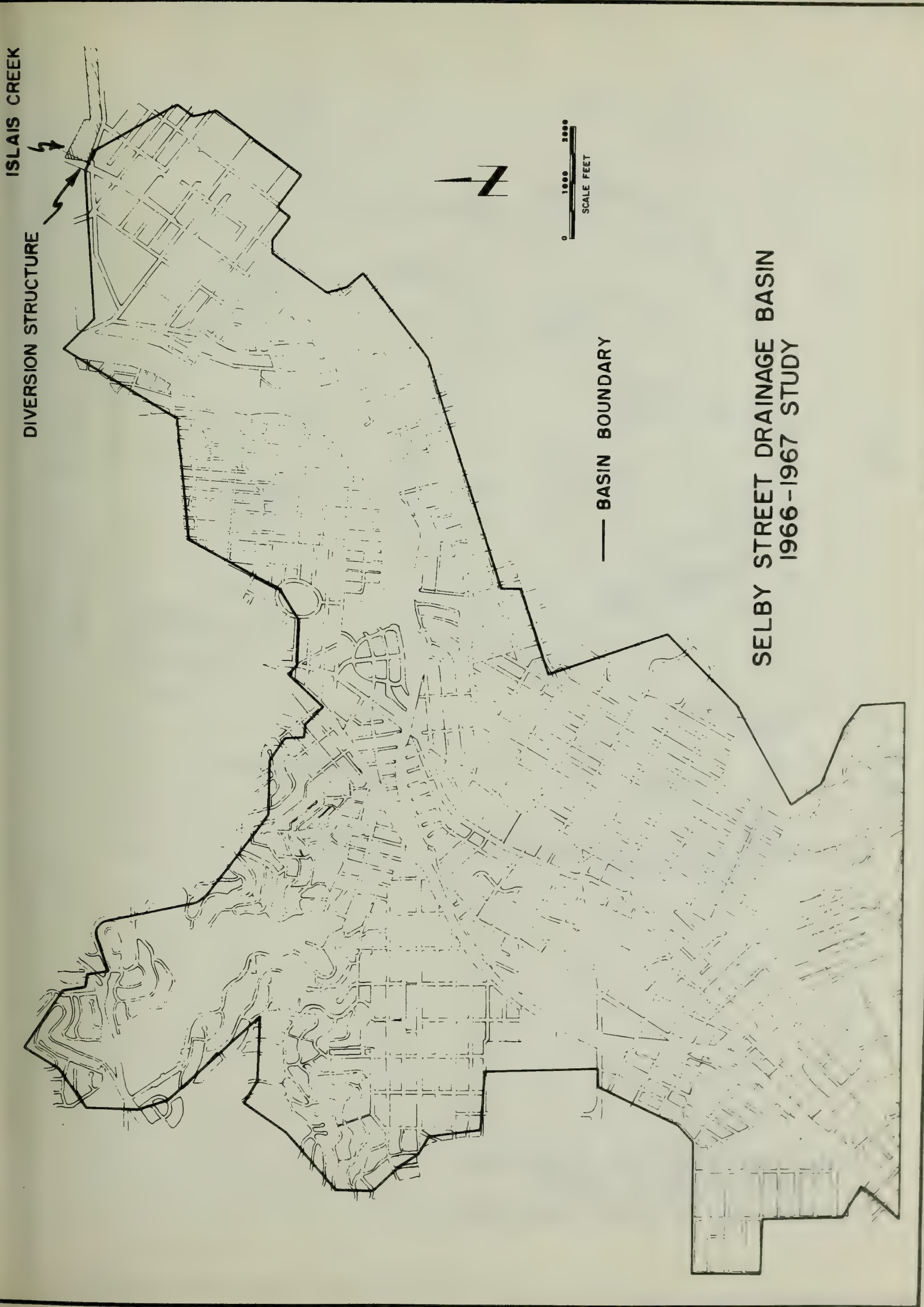
VICENTE STREET DRAINAGE BASIN
1969 - 1970 STUDY

FIGURE IV-6

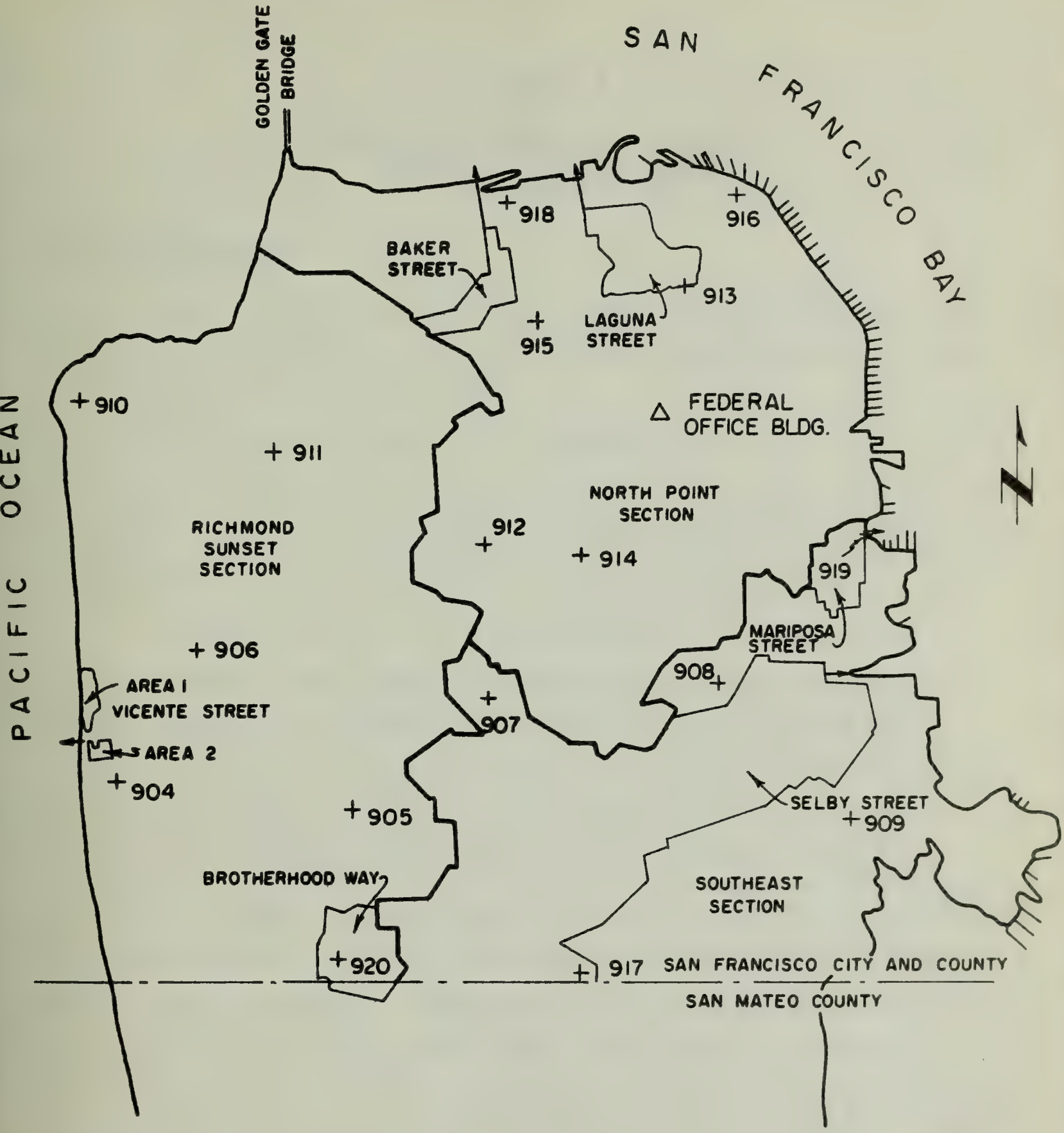


LAGUNA STREET DRAINAGE BASIN
1966-1967 STUDY

FIGURE IV-7



SELBY STREET DRAINAGE BASIN
1966-1967 STUDY



RAINGAUGE NETWORK (1969-1970)
BUREAU OF ENGINEERING
CITY AND COUNTY OF SAN FRANCISCO

CHAPTER V

QUANTITY AND QUALITY RELATIONSHIPS FOR COMBINED SEWER FLOWS

EVALUATION APPROACH

The nature of the information developed in the field program permits the examination of quality and quantity relationships for several types of drainage areas, as related to:

(1) Dry weather flows in five drainage areas.

(2) Combined sewage emissions in five drainage areas, due both to dry weather sewage flow, storm water (surface) runoff, and scour of deposits from the sewer and catch basins as a result of surface runoff.

(3) Storm water runoff from two areas of one drainage basin.

Dry weather sewage flows can be described in terms of hourly and diurnal variations of wastewaters derived from and reflecting the human, commercial, and industrial activities of an area, some of which may change as climatic conditions vary. Combined sewage quality reflects the net effect of intermixing storm water runoff and dry weather flows and the scouring of deposits from the system. The quantity and quality of combined sewage flows is controlled by the characteristics of the drainage basin as well as by those activities generating dry weather flows. Storm water runoff quantity is related to the character of the drainage basin; and storm water runoff quality, as observed in the field program, is related, not only to the character of the drainage basin, but also to the scouring phenomena (*i.e.*, the scouring of deposits from either the sewerage system or the surface during runoff).

A distinction at this point is required between combined sewage flows and combined sewage overflows. A combined sewage flow is defined as the aggregate flow upstream from the bypass structure under wet weather conditions. A combined sewer overflow is defined as that portion of the combined sewage flow that is bypassed, the

remaining portion of the combined sewage flow being diverted to the dry weather system at a rate (in San Francisco) theoretically equal to 0.02 in./hr. At lower rainfall rates, a significant portion of the combined sewage flow is diverted directly into the dry weather system rather than over a bypass structure.

Because of the above feature in the sewerage system, emphasis was directed to studying the composition of combined sewage flows and not to assessing how the climatic factors and system-dependent characteristics functioned to adjust the portion of the combined sewage flow diverted to receiving waters. Emphasis was also placed on estimating the impact of storm water runoff and system scour on the quantity and quality of combined sewage flow, in order to establish a basis for evaluating these factors as a function of the drainage area and its sewerage system. This approach was facilitated by establishing the net (or "due-to-storm") runoff and constituent mass emission rates during wet weather as the difference between these respective parameters for combined sewage flows and time-correspondent dry weather flows and mass emission rates. Net runoff and mass emission rates were established by this procedure for each storm monitored in the Baker Street, Mariposa Street, Selby, Laguna, and Brotherhood Way drainage basins, and for the storms monitored in the Vicente Street separate storm sewer system. The data on net mass emission rates for the Selby and Laguna Street drainage basins were obtained directly from the 1966-1967 study (Reference V-1).

The net or "due-to-storm" coefficients were then evaluated using data normalization techniques in an attempt to establish predictive relationships between drainage basin and sewerage system character and the quantity and quality of the combined sewage flows resulting therefrom. The basin-dependent parameters used in normalizing the net coefficients include land area, miles of street, and population density. This data analysis procedure resulted in the development of generally-applicable quantity and quality relationships for combined sewage flows as discussed subsequently in this chapter.

DRY WEATHER FLOW CHARACTERISTICS

Dry weather flows were characterized in the Baker Street, Mariposa Street, and Brotherhood Way sewer systems during May and June 1969. The flow and constituent concentration data, and mass emission rates of constituents derived from these data, are summarized in Appendices B, C, and D, respectively. Included in each of these appendices are figures illustrating the diurnal variation of dry weather flow and mass emission rates for specific 24-hour monitoring periods. Per capita flow and mass emission coefficients for the dry weather flows from the Baker, Mariposa, and Brotherhood basins, as well as for the Selby and Laguna basins (the latter from Reference V-1), are summarized in Table V-1, and flow-weighted mean concentrations are summarized in Table V-2.

Flow

The daily per capita flow rates (Table V-1) varied from a minimum of 81 gcd (gallons per capita per day) in Brotherhood basin to 131 gcd in the Baker basin. The average per capita flow for all basins was 106 gcd, as compared with a city-wide mean of approximately 133 gcd (Reference V-2). The per capita flow rate in the primarily residential areas (Baker, Brotherhood, and Selby) appeared to increase as the assessed value of the residential area increased; *i.e.*, 131 gcd in Baker basin versus 81 gcd and 96 gcd in Selby and Brotherhood basins, respectively. The per capita flow rates in the Mariposa basin (114 gcd; primarily industrial) and in the Laguna basin (107 gcd; residential/commercial) were approximately equal to the average rate of 106 gcd for all basins.

The observed rates of flow on an hourly basis in the Baker, Mariposa, and Brotherhood basins are shown in Figure V-1. The data show typical flow variations expected for municipal sewage, with maximal flows occurring during morning and evening hours and minimal flows occurring in the early pre-dawn hours.

Physical-Chemical Characteristics

The flow-weighted mean concentrations of the constituents of dry

TABLE V-1

AVERAGE DRY WEATHER FLOW AND MASS EMISSION COEFFICIENTS

Characteristic	Per Capita Mass Emission Rate, lb/capita/day or as noted					
	Baker Street[(2)]	Mariposa Street[(2)]	Brotherhood Way[(2)]	Selby Street[(3)]	Laguna Street[(3)]	Average, All Areas
Flow (cfs)	2.64	0.80	0.64	12.1	4.2	-
Flow (gcd)[(1)]	131	114	81	96	107	106
COD	0.321	0.320	0.374	0.369	0.383	0.353
BOD	-	-	-	0.136	0.159	0.148
TSS	0.142	0.131	0.165	0.165	0.173	0.155
VSS	0.122	0.095	0.146	0.118	0.144	0.125
Floatables	0.0020	0.0070	0.0090	0.0025	0.0025	0.0046
HEM	0.062	0.041	0.075	0.029	0.040	0.049
Total Nitrogen	0.020	0.025	0.029	0.026	0.028	0.026
Ammonia Nitrogen	0.007	0.012	0.009	-	-	0.009
Orthophosphate-P	0.0064	0.0053	0.0064	0.0069	0.0070	0.0054

NOTES: (1) gcd: gallons per capita per day; city-wide average @ 133 gcd (Reference V-2).

(2) Dates sampled (this study)

Baker Street: 19-20 May 1969
Mariposa Street: 2-3 June 1969
Brotherhood Way: 16-17 June 1969

(3) Dates sampled (Reference V-1):

Selby Street: 6, 8-9, 11-12, 17-18, 21, 23-24, and 26-27 September; 2-3 October 1966.
Laguna Street: 6, 8-9, 11-12, 17-18, 20-21, and 23-24 September 1966.

TABLE V-2

DRY WEATHER FLOW-WEIGHTED MEAN CONCENTRATIONS

Characteristic	Flow-Weighted Mean Concentration, mg/1				
	Baker Street	Mariposa Street	Brotherhood Way	Selby Street(1)	Laguna Street(1)
COD	294	337	553	466	430
BOD	-	-	-	170	179
TSS	130	138	244	206	194
VSS	112	100	216	147	162
Floatables	1.8	7.4	13.3	3.1	2.8
HEM	56.8	43.1	111	36	45
Total Nitrogen	18.3	26.3	42.9	32	31
Ammonia Nitrogen	6.4	12.6	13.3	-	-
Orthophosphate-P	5.9	5.6	9.5	9.6	7.9

NOTE: (1) Data for Selby Street and Laguna Street systems from Reference V-1.

weather flows are presented in Table V-2. The relative strengths of the dry weather sewage varied inversely with per capita flow rate, with the strongest sewage (in terms of COD, TSS, VSS, and total nitrogen) occurring at Brotherhood Way and the weakest at Baker Street. No significant peak mean concentrations were observed in any of the basins having commercial or industrial activity (Laguna or Selby).

The mass emission coefficients for each of the characteristics in Table V-2 are presented in Table V-1. The average mass emission coefficients, expressed as pcd or pounds per capita per day, are as follows: COD, 0.353 pcd; BOD, 0.148 pcd; TSS, 0.155 pcd; HEM (hexane extractable material), 0.045 pcd; floatables, 0.0046 pcd; total nitrogen, 0.026 pcd; and orthophosphate phosphorus, 0.0054 pcd. The lowest coefficients for each of these characteristics were generally associated with the Mariposa and Baker basins, both of which have, with the exception of the Selby basin, the lowest population densities (Table IV-1). The highest coefficient values were found in the Laguna and Selby basins, each of which has industrial and commercial as well as residential land uses. The greatest variation among basins was found in the coefficients for HEM and floatables, which varied for specific basins from one-half to twice the average values (Table V-1).

The particle-size distributions of the total suspended solids (TSS) were determined by sequential filtration of sample aliquots through 74, 14, 5, and 0.45 μ membrane filters. Individual data on the percent initial sample TSS retained on the above sequence of filters were developed for all dry weather flow samples taken in each basin. The individual data have been aggregated and ranked in data distributions for each type of filter, as a basis for establishing the median percent retention of TSS as a function of nominal filter pore size. The best-fit straight lines describing these data distributions are shown in Figure V-2. There were no discontinuities in the data distributions to indicate that two different data sets were being combined to form the data distributions from which the best-fit straight lines were developed. The analysis indicates that the median percent removal of TSS was as follows: 50 percent on 74 μ filter;

45 percent between 74 μ and 14 μ filters; seven percent between 14 μ and 5 μ filters; and four percent between 5 μ and 0.45 μ filters. Thus, the removal of about 95 percent of the TSS burden of dry weather flows is indicated in the median case after sequential filtration through 74 μ and 14 μ filters.

Coliform MPN

Data distributions of coliform MPN concentrations determined in the dry weather sampling effort are presented for each basin in Figure V-3. Included in Figure V-3 are data developed in dry weather monitoring surveys at Selby and Laguna basins in 1967 (Reference V-1). Best-fit lines are shown in Figure V-3 for each of the data distributions. The median coliform MPN concentration indicated for each basin by the best-fit curves can be used to define relative differences in coliform levels among the five basins. The median values of dry weather coliform MPN concentrations were:

(1) Brotherhood Way:	46×10^6 MPN/100 ml
(2) and (3) Selby and Laguna Streets:	33×10^6 MPN/100 ml
(4) Mariposa Street:	24×10^6 MPN/100 ml
(5) Baker Street:	14×10^6 MPN/100 ml

The median coliform levels vary by a factor of three between minimal and maximal levels (Baker Street vs. Brotherhood Way). There is a specific trend identifiable between median coliform MPN concentrations and strength of sewage as discussed previously. Additionally, as light industrial activities increase, coliform concentrations decrease. In both instances, the highest coliform MPN concentrations and sewage strengths were observed in the Brotherhood basin and the lowest levels were detected in the Baker basin.

COMBINED SEWAGE CHARACTERISTICS (Baker, Mariposa, and Brotherhood Drainage Basins)

Combined sewage flows were characterized in the Baker, Mariposa, and Brotherhood drainage areas between February 1969 and January 1970.

Three storms were monitored in each basin; the flow and constituent concentration data from these monitoring efforts, and mass emission rates calculated from these data, are summarized in Appendices B, C, and D for the Baker, Mariposa, and Brotherhood Way basins, respectively. Figures illustrating the rainfall-combined sewage flow hydrographs for each storm in each basin and typical concentration-time profiles for one storm per basin are included in this chapter; figures showing the concentration-time profiles for the remaining storms monitored in the Baker, Mariposa, and Brotherhood Way basins are included in Appendices B, C, and D, respectively.

The results of the storm sewer monitoring in the Vicente Street drainage basin are discussed in the next section.

Hydrology

The rainfall-combined sewage flow hydrographs for the storms monitored at Baker Street are shown in Figure V-4; hydrographs for the Mariposa storms are shown in Figure V-5; and for the Brotherhood storms in Figure V-6. The rainfall data were obtained either from project raingauges located in each basin at the time of monitoring or from the United States Weather Bureau raingauge at the Federal Office Building, San Francisco. The combined sewage flow measurements in all cases were developed within the project using the dye-dilution technique cited in Appendix A.

The combined sewage flow hydrographs shown in Figures V-4 to V-6 were adjusted by subtraction of the corresponding dry weather flow to permit estimation of a net or "due-to-storm" runoff quantity for each basin. The runoff quantity was estimated as the corrected volume of flow only for the time during which overflow occurred, a factor which would not consider the fraction of the runoff quantity (as the total combined sewage flow receded to base or dry weather flow) that was directed to the dry weather sanitary sewage system after cessation of the diversion. This latter fraction amounted to less than five percent of the runoff quantity for the storms monitored inasmuch as the receding flow for all storms was never more than twice dry weather

flow, whereas peak flows during the overflow period were generally in excess of 10 times dry weather flow rates.

In estimating the quantity of rainfall contributing to the runoff quantity, it was necessary to establish a criterion for selecting the period of time prior to start of overflow that rainfall contributed to the runoff quantity for the overflow. The selected criterion was to include all precipitation occurring within one time of concentration prior to start of overflow in cumulative storm rainfall. The criterion was used for all overflow/storm monitoring events where precipitation occurred for an extensive period prior to monitoring of combined sewer flow.

A summary of the hydrologic data for the monitored storm (including net runoff, rainfall, and runoff factors developed as discussed above) is presented in Table V-3. The cumulative rainfall varied from 0.02 to 0.64 inches for the storms monitored. Rainfall intensities observed in the monitored storms varied from 0.01 to 0.80 in./hr, the average value being 0.07 in./hr. The average rainfall value observed in the 1966-1967 studies (Reference V-1) was approximately 0.15 in./hr.

As a basis of comparison, a recent analysis of hourly rainfall records taken at the Federal Office Building over the past 62 years and of five-minute intensity records over the past 17 years has indicated that, on an hourly basis, the rainfall intensity distribution has the following characteristics:

(1) 0.01 in./hr was exceeded 90 percent of the time.

(2) 0.02 in./hr was exceeded 75 percent of the time.

(3) 0.03 in./hr was exceeded 50 percent of the time.

(4) 0.13 in./hr was exceeded 10 percent of the time.

(5) 0.18 in./hr was exceeded 5 percent of the time.

Thus, the average intensity of the storms monitored in this study is exceeded approximately 20 percent of the time and that of the previous study is exceeded less than 10 percent of the time. It is noted that the average intensity of rainfall in the San Francisco storms monitored in this

TABLE V-3

HYDROLOGIC DATA FOR MONITORED STORMS

Drainage Basin	Date of Storm	Rainfall (inches)	Net Runoff (acre-in.)	Runoff Factor (percent)	Antecedent Dry Period (days)	Monitoring or Runoff Duration (hours)
Baker Street	4-5 April 1969	0.25	48.2	114	1	2
	15 October 1969	0.23	26.8	70.1	<1	3
	5 November 1969	0.64	82.0	77.8	19	5
Mariposa Street	27-28 Feb 1969	0.31	57.7	79.8	<1	8
	20 March 1969	0.18	30.4	70.9	1	5
	2 April 1969	0.06	7.62	58.3	12	1
Brotherhood Way	14 Jan 1970	0.30	35.6	65.8	<1	4
	15 Jan 1970	0.42	22.6	29.9	<1	4
	23 Jan 1970	0.02	1.82	50.6	<1	3
Vicente Street (Area 1)	16 Feb 1970	0.39	7.68	121	2	5
Vicente Street (Area 2)	16 Feb 1970	0.39	5.92	72.8	2	5

and previous studies is considerably less than the average rainfall intensities experienced in many other sections of the United States.

Runoff factors were estimated for each monitored storm by dividing the "due-to-storm" flow by the rainfall volume as noted above. The calculated runoff factors for the storms at Baker Street varied from 70.1 to 114 percent; with exception of the runoff factor of 114 percent, the runoff factor averaged 74 percent at Baker Street for two storms. The calculated runoff factor at Mariposa Street varied from 58.3 to 79.8 percent; the average calculated runoff factor was 70 percent. The runoff factor determined for three storms at Brotherhood Way varied from 29.9 to 65.8 percent, and averaged 58.2 percent exclusive of the 20.0 percent runoff factor. It is unclear how the exceptionally high runoff factor at Baker Street (114 percent) and low value at Brotherhood Way (29.9 percent) were obtained. One possibility is the spatial and temporal variations in rainfall quantities as previously described. Another possibility is that of a diversion of the overland flow due to plugged catch basin inlets or due to flow that exceeded the capacity of the inlets. With the exception of these values, the average runoff factors presented above for the Baker, Mariposa, and Brotherhood drainage basins are within the range of values normally expected for the types of land use presented by these basins (Reference V-1).

Physical-Chemical Characteristics

Variation of Characteristics

Figures V-7 to V-10 illustrate concentration-time profiles for storms monitored, respectively, at Selby Street on 6 November, Baker Street on 5 November 1969, Mariposa Street on 20 March 1969, and Brotherhood Way on 14 January 1970. Figures illustrating the time-concentration profiles for the other storms monitored in the Baker, Mariposa, and Brotherhood Way basins are presented in Appendices B, C, and D, respectively.

The physcial-chemical characteristics of the overflows were examined from two perspectives:

(1) The time-variant nature of the concentration profiles as related to rainfall intensity and antecedent dry period.

(2) The concentration profiles as related to the characteristics of the drainage areas.

Previous studies at Selby Street (1967, Reference V-1) indicated that combined sewage pollutant concentration-time profiles in that basin could be described quanitatively as follows:

(1) An initial phase in which the combined sewage quality was analogous to sanitary sewage.

(2) A second phase in which the constituent levels in the combined sewage increased above those of sanitary sewage due to factors such as the scouring phenomena.

(3) A final phase in which combined sewage strength receded to that of a dilute sanitary sewage.

Within the initial prespective, the data developed in the present study were evaluated to ascertain what correlations could be found between rainfall intensity, rate of change of flow as a result of the rainfall, antecedent dry period, and the time-variant nature of the concentration profiles. An analysis was made of the initial rainfall intensity (at or prior to start of overflow), the initial flow rate (as observed at the start of the overflow), and the antecedent dry period for each monitoring event; the data compiled in this analysis are reported in Table V-4. The COD data for each storm were used to ascertain if peak concentrations had occurred in the overflows, indicative of a shift from the first to second phase of runoff as observed at Selby Street. The occurrence of peak COD levels within an hour after the onset of overflow was observed in only four of the nine storms that were monitored. In each case the occurrence of the peak was associated with the rapid rate of increase in the flow rate, indicating implicitly that the peak concentration was associated with a rapid increase in the levels of the scouring phenomena and of surface wash. In the several instances (Mariposa Street, 27-28 February 1969 and 20 March 1969; Brotherhood Way, 14 January 1969), delayed concentration peaks were observed after several hours of overflow had occurred; in each case the delayed peak was associated with a rate of increase in flow rate following an increase in rainfall intensity.

The parameter of antecedent dry period was not related consistently

TABLE V-4

FACTORS ASSOCIATED WITH TIME-CONCENTRATION PROFILES OF COMBINED SEWAGE OVERFLOWS

Drainage Basin	Date of Storm	Antecedent Dry Period	Initial Rainfall Intensity (in./hr)	Initial Flow Rate (cfs)	Time Interval to Occurrence of Peak COD (hours)
Baker Street	4-5 April 1969	1	0.055	15	0.5
	15 October 1969	<1	0.025	10	-
	5 November 1969	19	0.078	80	0.2
Mariposa Street	27-28 Feb 1969	<1	0.04	3	-
	20 March 1969	1	0.07	6	0.1
	2 April 1969	12	0.08	9	-
Brotherhood Way	14 January 1970	<1	0.035	27	-
	15 January 1970	<1	0.22	12	1.0
	23 January 1970	<1	0.01	0.4	-

NOTE: Initial rainfall intensity and flow rate as observed at onset of overflow.

with the occurrence of peak COD levels within an hour after onset of overflow. In three of the four cases where peak concentrations were observed within a one-hour time interval, the antecedent dry period was one day or greater (Table V-4). However, several storms were monitored after an antecedent dry period of one or more days had occurred in which no early peak COD concentrations were observed. Thus, the antecedent dry period does not appear to be a necessary condition for the occurrence of early peak concentrations.

The physical-chemical characteristics were also examined with respect to the character of drainage basins. The data shown for Baker Street in Figures V-8, B-1, and B-2 indicated that a tide of poorer quality water is pushed forward on each flow peak, followed by gradual decrease in concentration of characteristics to levels typical of dilute early morning sewage, and possibly reflecting the limited sump of curbside and other potentially washable materials in this basin. The concentration-time profiles for Mariposa storms (Figures V-9, C-1, and C-2) follow a pattern in which the variation of pollutant concentrations reflect strongly the variation in background dry weather concentrations rather than as a result of peak flow flushing to the sewer system. Additionally, the nature of much of the street refuse in the Mariposa basin (cardboard, glass, etc.) is such that not much material is potentially available for transport to the sewer system in surface runoff. The data presented for Brotherhood Way (Figures V-10, D-1, and D-2) indicate that an initial dilution took place (relative to the constituent levels which would be expected under dry weather conditions) and that the second phase as evidenced at Selby Street and Baker Street did not occur at Brotherhood Way. Again, little material, available for transport by surface runoff, was visibly evident in this basin.

On the basis of the foregoing observations, it is apparent that the three-phased time-concentration profiles reported in the previous study for Selby Street do not have a specific utility in predicting variation of pollutant profiles for combined sewage flows in the basins monitored in the present study. The foremost factor associated with the occurrence of concentration peaks in the basins monitored in

the present study was the rate of change in flow rate following a burst of rainfall, suggesting that the components of the scouring phenomena are factors related to the peak concentrations.

No direct relationships between time-concentration profiles and drainage basin characteristics were indicated from the above observations. The scope of the present study precluded detailed study of the impact of basin characteristics or features (such as catch basin flushing) on surface runoff quality or actual measurement of the effect of material scour from the sewers on combined sewage quality. In the absence of sufficiently detailed information, a more general approach was taken to assess the utility of the physical-chemical data for formulating a predictor relationship between drainage basin character and "due-to-storm" constituent emissions; that approach (entailing development of normalized "due-to-storm" mass emissions coefficients) is presented subsequently in this chapter.

Another aspect of the relationship between time-concentration profiles and basin characteristics relates to the levels of rainfall intensity required as a driving force to effect transport of materials from a reservoir in a basin to the combined sewer system. The average rainfall intensity of storms monitored in this study was 0.07 in./hr a level which is significantly below that realized in many areas of the country. It is unknown what "threshold" intensity level is required to effect the transport required to perceive the impact of land quality in a basin on the quality of combined sewage flow. Consequently, the information generated in this study must be considered in terms of rainfall intensity when compared with studies done elsewhere.

Size Characteristics of Suspended Solids

The particle-size distributions of TSS in samples of combined sewage flows from each basin were determined by sequential filtration as discussed in Appendix A. Data distributions were developed for the resultant data on the percent TSS retained sequentially on the 74, 14, 5, and 0.45 μ membrane filters. In order to establish the median percent retention of TSS as a function of nominal pore size, two distinct types of particle-size distributions were developed: a set

for Vicente Street and Brotherhood Way data taken together, in which the median TSS retention level were similar to those for dry weather flows discussed previously; and a second set for Baker Street and Mariposa Street data taken together, which differed significantly from the Brotherhood/Vicente data set. Because of the similarity between the first data set for Brotherhood/Vicente combined sewage samples with the dry weather flow information, effort was directed to analyses of the second data set. The best-fit lines describing the data distributions for the second set are shown in Figure V-11. The median percent removal of TSS was as follows: 30 percent on 74 μ filter; 63 percent between 74 μ and 14 μ filters; five percent between 14 μ and 5 μ filters; and one percent between 5 μ and 0.45 μ filters. Thus, the median removal of about 95 percent of the TSS burden in the combined sewage flows was obtained by sequential filtration through 74 μ and 14 μ filters. This level is identical to the median level achieved in the sequential filtration of dry weather flow samples; however, the 74 μ filter was nearly twice as effective (median 50 percent removal) in the removal of TSS from dry weather samples as compared with combined sewage samples from Baker Street and Mariposa Street.

Coliform MPN

Data distributions of coliform MPN concentrations were developed from combined sewage monitoring data for each of the basins as discussed previously for the dry weather coliform data. The coliform MPN data distributions for the Baker, Mariposa, and Brotherhood drainage basins are plotted in Figure V-12. Similar data distributions for the Selby and Laguna basins were developed from data reported in Reference V-1 and are plotted in Figure V-13. A preliminary plot of the data distribution for Baker Street indicated that two, rather than one, sets of data were incorporated in the distribution. The evidence that two data sets, rather than one, were involved, was that the total distribution could not be described adequately by a single best-fit curve. The data set having the higher range of coliform MPN concentrations was found to be associated with COD concentrations in the combined sewage flow in excess of 500 mg/l and the second set was associated

with periods of dilute combined sewage flow. The data distributions for the other basins can be described by a single best-fit line, as evidenced by information presented in Figures V-12 and V-13.

The median coliform MPN concentrations from the data distributions for each basin are shown in Table V-5. Included in Table V-5 are the dry weather median coliform MPN concentrations for each of the basins. The combined sewage median coliform MPN concentrations for the basins other than the Baker Street basin varied from six to 36 percent of the respective dry weather median coliform MPN levels. The median coliform MPN level for the combined sewage high data set at Baker Street was 128 percent of the dry weather median coliform MPN level and the median level for the low data set was 13 percent of the dry weather median level. It is apparent from this comparison that the combined sewage median coliform MPN level was significantly less than corresponding dry weather levels at Mariposa, Brotherhood, Selby, and Laguna basins for the storms monitored. Because the data distributions for these basins could be described by single best-fit lines, a direct relationship between factors such as time after start of overflow or combined sewage flow as a multiple of dry weather flow and the coliform MPN concentration is not indicated. The need for two data sets to describe coliform MPN concentrations for the Baker Street basin is evidence of a positive relationship between coliform MPN levels and degree of dilution of dry weather flow in the combined sewage flows from this basin. Additional information is required to ascertain if this and the relationship would hold for all the basins over a wide range of rainfall intensities. The results of this study indicated that approximately a 10-fold difference in the coliform MPN levels of combined sewage flow from the Baker Street basin can be expected as the COD level in the flow is reduced from dry weather levels (approximately 300 mg/l) to less than 80 mg/l.

Toxicity Bioassays

Toxicity bioassays were performed routinely on two or more samples per storm monitored in each basin. The test fish used for the bioassays was the "Stickleback" (*Gasteroseus aculeatus*), a fish indigenous to

TABLE V-5

MEDIAN COLIFORM MPN CONCENTRATIONS

Basin	Median Coliform MPN Concentration (10^6/100 ml) Combined Sewage	Median Coliform MPN Concentration (10^6/100 ml) Dry Weather	Wet Weather Median (percent of dry weather median)
Baker Street			
(high data set)	16	14	128
(low data set)	1.8	14	13
Mariposa Street	7	24	29
Brotherhood Way	2.9	46	6
Selby Street	12	33	36
Laguna Street	5.4	33	16

NOTE: Data for Selby and Laguna basins from Reference V-1.

San Francisco Bay. A summary of the bioassay results is presented in Table V-6. The 96-hr TL_m (median tolerance level) determination was performed on initial samples for bioassay (Mariposa Street, 27-28 February 1969); however, these initial tests indicated that the 96-hr TL_m of the samples was >100 percent and that a simpler "96-hr percent survival" test could be used. The results presented in Table V-6 indicate that the minimum percent survival in samples from Baker, Mariposa, and Brotherhood Way was 80 percent and that 100 percent survival occurred in nine of the total of 13 samples from these basins. No correlation was observed between time after start of overflow or ratio of wet to average dry weather flow rates and the 96-hr percent survival. Also, no correlation was observed between COD or TSS concentrations in the samples and the 96-hr percent survival levels.

Mass Emission Rates

Net or "due-to-storm" mass emission rates have been calculated for all sampling intervals for the nine storms monitored in the three combined sewer systems, and are discussed subsequently in this chapter.

STORM SEWAGE CHARACTERISTICS (Vicente Street Drainage Basin)

Storm sewage flows were characterized in the two subareas of the Vicente Street drainage basin, each on one occasion, in February 1970. The flow and constituent data from these monitoring efforts and mass emission rates for the storms are summarized in Appendix E.

Hydrology

The rainfall-storm sewage flow hydrographs for Areas 1 and 2 are shown in Figure V-14. Rainfall data and flow measurements were developed as discussed previously using project equipment. The maximum rainfall intensity for the monitored storm was 0.12 in./hr and the average intensity was less than 0.10 in./hr. The flow hydrographs in Figure V-14 are assumed to represent only storm runoff quantities for each area, and a close correlation is apparent between rainfall and flow magnitudes. The runoff factors (volume basis) observed for the basin are 121 percent for Area 1 and 72.8 percent for Area 2 (Table V-3).

TABLE V-6

SUMMARY OF BIOASSAY RESULTS

Basin	Storm Date	Time After Start of Overflow (minutes)	Sample COD (mg/1)	Sample TSS (mg/1)	Ratio of Wet to Average Dry Weather Flow Rates	96-hr TL_m (percent by volume)	% Survival, Undiluted Waste (96-hr)
Baker Street	15 October 1969	30	60	42	2.9	-	100
		210	174	61	4.8	-	100
	5 November 1969	10	183	80	16.3	-	80
		50	261	246	4.3	-	100
		220	151	79	5.5	-	100
Mariposa Street	27-28 February 1969	10	131	156	2.9	>100	-
		97	129	42	4.0	>100	-
		187	127	114	1.6	>100	-
Brotherhood Way	14 January 1970	0	154	154	42.2	-	100
		90	58	58	5.9	-	100
	15 January 1970	0	43	91	16.9	-	100
		30	64	56	17.8	-	90
		240	78	21	7.8	-	90
	23 January 1970	50	152	30	0.9	-	100
		127	88	49	1.2	-	100
		169	187	110	1.4	86	0
Vicente Street (Area 1)	16 February 1970	0	428	210	-	-	30
		45	80	30	-	-	90
Vicente Street (Area 2)	16 February 1970	0	184	210	-	-	0
		45	87	70	-	-	100

NOTES: Average dry weather flow rates

Baker Street sewer: 2.64 cfs
Mariposa Street sewer: 0.80 cfs
Brotherhood Way sewer: 0.64 cfs
Vicente Street storm sewer: Nil

Preliminary investigation of the storm sewer systems of these areas indicated that essentially zero flow occurs in these sewers under dry weather conditions. Documentation is incomplete as to whether any sanitary sewers are tied into the system or whether storm waters are diverted from another system into the Vicente system. In consideration of the character of the two areas monitored in the Vicente basin (Chapter IV) a runoff factor of 70 to 80 percent was anticipated. Consequently, it is possible that flows of storm or sanitary sewage of undocumented origin are associated with the high runoff factor observed in Area 1.

Physical-Chemical Characteristics

Time-concentration profiles for the storm monitored in Area 1 and Area 2 are shown in Figure V-15. The profiles indicate that a two-phase variation of concentration over time is taking place, *viz.*, initial peak levels decreasing rapidly within two hours to levels of 10 to 20 percent of the original values. The initial strength of the storm sewage flow from Area 1 was equivalent in all characteristics but nitrogen, orthophosphate-phosphorus, and coliform MPN levels to initial samples of combined sewage flow taken elsewhere; however, the initial sample strength in Area 2 was about one-half that of Area 1 in terms of COD and nutrients. The higher initial strength of the storm sewage flow derived from Area 1 (totally residential) relative to Area 2 (residential, commercial, and zoo areas) raises additional question as to whether sanitary or combined sewage enters the Area 1 sewerage system.

The particle-size distributions of TSS in samples of storm sewage flows from each basin were determined by sequential filtration as discussed previously. The mean percent TSS values retained on 74, 14, 5, and 0.45 μ membrane filters are as follows (Areas 1 and 2):

(1) 74 μ: 80.4 percent.

(2) 14 μ: 9.2 percent.

(3) 4.5 μ: 5.8 percent.

(4) 0.45 μ: 4.5 percent.

Thus, the 74 µ filter was effective in removing a mean 80 percent of the TSS burden in the storm sewage, and the 74 µ and 14 µ filters effectively removed a mean level of nearly 90 percent of the TSS. The mean 90 percent TSS removal achieved by sequential filtration through the 14 µ filter is similar to the median 95 percent removals achieved with the 74 µ and 14 µ filters for combined sewage and dry weather samples as discussed previously.

Coliform MPN

The coliform MPN concentrations in both areas of the Vicente basin varied randomly over the period of monitoring; and no distinct trend (increasing or decreasing MPN levels) was evident (Tables E-2 and E-3 of Appendix E). For this reason data distributions were developed for the coliform MPN data from each area and are shown in Figure V-16. Because only one storm was monitored in each area, a limited number of data was available to define the distributions. The median coliform MPN levels were found to be 7 × 10^5/100 ml in Area 1 and 1.6 × 10^5/100 ml in Area 2. The median levels for each area are proportional to the initial strengths of the storm sewage samples from these areas. The median value for Area 1 (7 × 10^5 MPN/100 ml) is about five percent of the median coliform MPN concentration in the dry weather flow at Baker Street (Table V-5). The median coliform level of 1.6 × 10^5 MPN/100 ml in Area 2 is about one percent of the dry weather flows at Baker Street. This comparison indicates that median coliform MPN levels in Vicente Street storm sewage are from one to two orders of magnitude less than median MPN levels in dry weather flow. However, these levels still exceed the standards for water contact sports, *viz.*, 240 MPN/100 ml.

Toxicity Bioassays

The results of toxicity bioassays done on storm sewage samples from Area 1 and Area 2 are reported in Table V-6. The samples tested were taken at the start of runoff in Area 1 and 45 minutes after start of runoff in Area 2. The Area 1 samples were found to have the strength of initial combined sewage samples (*e.g.*, COD of 428 mg/l, Table E-2 of Appendix E). The Area 2 sample had a COD of less than 100 mg/l. The 96-hr percent survival was 30 percent in the Area 1 sample and 90 percent in the Area 2 sample. It is evident that the storm runoff

strength as observed in Areas I and 2 of the Vicente basin had a significant effect on the toxicity of the sample to the test organisms (stickleback).

NET MASS EMISSION COEFFICIENTS

A combined sewage flow has been considered in this report as the aggregation of dry weather flow and storm water runoff, with the qualification that the flushing and scouring of deposits in a combined or storm sewer system may in some systems have a greater measurable impact on the quality of the total flow than in other systems. From an engineering perspective it is desirable to be able to "reconstruct" the character of a combined sewage flow so that alternative situations of drainage basin, sewer system, and hydrology can be presented and evaluated with respect to wastewater loads. In previous discussion, average dry weather flow and mass coefficients (per capita basis) were presented (Table V-I); these coefficients can be used to evaluate on a daily basis the dry weather flows and loads from any drainage basin having characteristics similar to those of the basins studied in San Francisco.

As a complement to the dry weather coefficients, a similar type of coefficient is needed to relate wastewater loads due to stormwater-generated flows on a normalized or coefficient basis, reflecting the character of the area and magnitude or rate of the rainfall or runoff generating the wastewater loads. The approach used in this section was to normalize the cumulative net mass emissions (lb per storm) of key constituents against basin dependent characteristics (population density, miles of street, etc.) as well as combined basin-dependent and runoff parameters such as acre-inch of runoff. Because the general effort of the investigation was directed to study a number of basins in a broad sense rather than to one basin in detail, is was not possible to approach the development of stormwater coefficients from a more detailed level (such as consideration of catch basin census, etc.). The constituents selected for normalization were: COD, TSS (total suspended solids); TN (total nitrogen); OPP (orthophosphate-phosphorus); HEM (hexane extractable material); and floatable materials.

Normalization of Cumulative Net Mass Emission Data

Cumulative net mass emission and runoff data are summarized for the 11 events monitored in this study and 9 events monitored in 1966-1967 (Reference V-1) in Tables V-7 to V-9. COD, TSS, TN, and OPP data are presented for the Baker, Mariposa, Brotherhood, and Vicente basins in Table V-7 and for the Selby and Laguna basins in Table V-8. HEM and floatables data are reported for all basins in Table V-9.

The initial step taken in the normalization process was directed to examining possible correlations between the following parameters:

(1) lb/acre-of-drainage basin vs. inches runoff.

(2) lb/mile street vs. inches runoff.

(3) lb/population density in drainage basin vs. inches runoff.

(4) lb/acre-inch vs. inches runoff.

The selection of these parameters was based on (1) information available and furnished by the City of San Francisco, and on (2) the relationship between these parameters and stormwater runoff as described in studies elsewhere (*e.g.*, References V-3 and V-4). The basic premise indicated by these and other previous studies is that the above mass parameters other than lb/acre-inch would be expected to increase at a decreasing rate with increasing runoff and that the latter parameter (lb/acre-inch) would decrease with increasing runoff.

These parameters were calculated for each of the six constituents for each storm, and the basic data developed from this effort are summarized in Appendix J.

In order to evaluate the relationships defined by these parameters, several alternative deterministic relationships were examined. Figures V-17 to V-20 illustrate the plots developed using the COD data as follows:

(1) Figure V-17: COD-net emission per acre vs. runoff (rectilinear scale).

(2) Figure V-18: COD-net emission per acre vs. runoff (semilog scale).

TABLE V-7

CUMULATIVE NET MASS EMISSION AND RUNOFF (DUE-TO-STORM)

BAKER, MARIPOSA, BROTHERHOOD, AND VICENTE DRAINAGE BASINS

Basin	Date of Storm	Runoff (in.)	Net Mass Emission (lb)			
			COD	TSS	Total Nitrogen	Ortho-phosphate-P
Baker Street	4-5 April 1969	0.29	749	1,030	217	24.9
	15 October 1969	0.16	347	402	20.7	25.0
	5 November 1969	0.50	3,110	1,500	142	9.93
Mariposa Street	27-28 February 1969	0.25	614	1,020	6.96	28.5
	20 March 1969	0.14	1,700	1,930	5.14	2.63
	2 April 1969	0.035	777	621	11.8	22.5
Brotherhood Way	14 January 1969	0.20	597	7,573	82.7	5.9
	15 January 1969	0.13	21.5	287	94.3	27.6
	23 January 1969	0.01	217	1,230	-0.06	2.28
Vicente St. (Area 1)	16 February 1969	0.58	67.9	37.0	2.83	0.08
Vicente St. (Area 2)	16 February 1969	0.54	139	62.1	0.96	0.07

TABLE V-8

CUMULATIVE NET MASS EMISSION AND RUNOFF (DUE-TO-STORM) SELBY AND LAGUNA DRAINAGE BASINS

Basin	Date of Storm	Runoff (in.)	Net Mass Emission (lb)			
			COD	TSS	Total Nitrogen	Ortho-phosphate-P
Selby Street	6 November 1966	0.35	91,900	199,400	2,020	336
	14-15 November 1966	0.25	25,900	19,200	1,370	183
	20 January 1967	3.19	232,500	402,900	890	327
	23 January 1967	0.61	48,100	96,900	830	276
	24 February 1967	0.03	18,400	16,800	490	40
	10 March 1967	0.42	57,100	153,000	1,130	52
	15 March 1967	0.26	29,400	59,000	640	199
Laguna Street	10 March 1967	0.35	3,820	9,930	83	-
	15 March 1967	0.39	2,600	4,270	57	6

Source: Reference V-1

TABLE V-9

CUMULATIVE NET MASS EMISSION AND RUNOFF (DUE-TO-STORM)

BAKER, MARIPOSA, BROTHERHOOD, VICENTE, SELBY, AND LAGUNA DRAINAGE BASINS

Basin	Date of Storm	Runoff (in.)	Net mass Emission (lb)	
			Hexane Extractable Materials (HEM)	Floatable Materials
Baker Street	4-5 April 1969	0.29	-29.2	39.7
	15 October 1969	0.16	13.4	3.92
	5 November 1969	0.50	382	30.1
Mariposa Street	27-28 February 1969	0.25	47.9	121
	20 March 1969	0.14	181.6	31.6
	2 April 1969	0.035	47.8	1.32
Brotherhood Way	14 January 1970	0.20	86.5	167
	15 January 1970	0.13	286	34.7
	23 January 1970	0.01	10.6	326
Vicente St. (Area 1)	16 February 1970	0.58	14.3	3.71
Vicente St. (Area 2)	16 February 1970	0.54	12.85	4.39
Selby St.*	6 November 1966	0.35	8,800	1,890
	14-15 November 1966	0.25	1,020	250
	20 January 1967	3.19	14,070	10,170
	23 January 1967	0.61	4,080	1,170
	24 February 1967	0.03	800	180
	10 March 1967	0.42	9,810	120
	15 March 1967	0.26	3,820	-
Laguna St.*	10 March 1967	0.35	710	136
	15 March 1967	0.39	290	32

Source: * Reference V-1.

(3) Figure V-19: COD-net emission per mile street vs. runoff (semilog scale).

(4) Figure V-20: COD-net emission per acre-inch vs. runoff (semilog scale).

It is apparent from an examination of Figures V-17 to V-20 that no correlation exists between any of the parameters tested. Attempts were made to disaggregate the data by basins having similar land use characteristics and antecedent dry periods, again without any success in terms of developing a correlation between the parameters considered. It is believed, but not substantiated within the scope of this study, that the low rainfall intensities of the monitored storms (<0.16 in./hr for this and the 1966-1967 study) have obviated against detection of the effect of specific land quality parameters on combined sewage quality.

The random nature of the data, as illustrated by Figures V-17 to V-20, indicated that the data could be treated as distributions and, from this perspective, could be examined to ascertain whether one or more data sets existed in the distribution, each set of which could be described in terms of a mean parameter value and a mean runoff value. Data distributions were developed for the lb/acre-inch parameter for each of the six constituents; the ranked data (one datum per storm for 20 storms) are summarized in Table J-9 of Appendix J. The lb/acre-inch parameter was selected on the basis that it represented the cumulative net emission from a basin normalized both as to area and to runoff. The data distributions for each constituent were grouped as shown in Table J-9 and plotted in Figures V-21 to V-26 for COD, TSS, TN, OPP, HEM, and floatables, respectively. The mean runoff was calculated for each group of data as a means of quantifying a runoff level associated with each data grouping. The runoff value of 3.19 inch for the Selby Street storm of 20 January 1967 was not included in the determination of the mean runoff for the data group in which the datum for that storm occurred.

Figure V-21 shows the two data sets developed for the COD data. The mean coefficient for the lesser data set was 23.5 lb/acre-inch and the mean runoff ($\bar{r}$) was 0.36 inch. The mean value for the higher set

was 98 lb COD/acre-inch at a mean runoff of 0.12 inch. The coefficient of variation (C_V) was approximately 50 percent for both COD data distributions. Three data sets were obtained for the TSS data, as shown in Figure V-22. The mean TSS coefficients of the three distributions were: 13.5 lb/acre-inch at $\bar{i}$ = 0.34 inch; 50 lb/acre-inch at $\bar{i}$ = 0.30 inch; and 157 lb/acre-inch at $\bar{i}$ = 0.19 inch. The coefficients of variation of the TSS data sets varied between 27 and 42 percent.

Figure V-23 illustrates the three data sets that were obtained for the total nitrogen data. The mean TN coefficients were: 0.4 lb/acre-inch at $\bar{i}$ = 0.34 inch; 1.75 lb/acre-inch at $\bar{i}$ = 0.27 inch; and 4.5 lb/acre-inch at $\bar{i}$ = 0.14 inch. The coefficients of variation for the TN data distribution varied from 16 to 70 percent. Three data sets were obtained for the OPP data as shown in Figure V-24. The mean OPP coefficients were: 0.15 lb/acre-inch at $\bar{i}$ = 0.36 inch; 0.48 lb/acre-inch at $\bar{i}$ = 0.19 inch; and 1.0 lb/acre-inch at $\bar{i}$ = 0.10 inch. The coefficients of variation for these data sets varied from 14 to 93 percent. A fourth data set was obtained for the OPP data with a mean OPP coefficient of 0 (as indicated in Table J-8 of Appendix J) and $\bar{i}$ = 0.43 inch.

Figure V-25 shows the three data sets that were obtained for the HEM data. The mean HEM coefficients were: 1.45 lb/acre-inch at $\bar{i}$ = 0.36 inch; 5.1 lb/acre-inch at $\bar{i}$ = 0.27 inch; and 10.2 lb/acre-inch at $\bar{i}$ = 0.10 inch. The coefficients of variation for the HEM distributions varied from 32 to 70 percent. Two data sets were obtained for the floatables data as presented in Figure V-26. The mean floatables coefficients were: 0.58 lb/acre-inch at $\bar{i}$ = 0.37 inch; and 1.6 lb/acre-inch at $\bar{i}$ = 0.22 inch. The coefficients of variation for the distributions were 28 and 83 percent.

There are several ramifications to the data presentations in Figures V-21 to V-26. First, several of the data sets contain only three or four pieces of data, a circumstance which follows from the limited number of data (20) in the total distributions. The reliability of the mean of a data distribution (*i.e.*, the percent of the time it is desired that a mean value fall within a standard error measure) is

controlled by the number of observations in the data distribution. The question as to how many observations are necessary can be based only on a predicted level of reliability and on foreknowledge of the nature of the inherent variability of the individual observations. Because of the limited number of opportunities (*i.e.*, storms) in this study for obtaining observations for the data distributions, there is no firm basis for testing the statistical acceptability of the data distributions as developed and presented in this section. In the absence of a reliability criterion, the mean values of the data sets in Figures V-21 to V-26 were accepted as descriptive of the parameter of concern without statistical evaluation.

The second ramification of the data distributions in Figures V-21 to V-26 is that a correlation is evident between mean parameter value (lb/acre-inch) and mean runoff, *i.e.*, the mean parameter value decreases as mean runoff increases in accordance with the type of relationship predicated previously. Figure V-27 illustrates graphically the correlations observed for COD, TSS, and TN coefficients, and the correlations for OPP, HEM, and floatables coefficients are shown in Figure V-28. From two to three points (each described by mean coefficient value and mean runoff) were available to define the correlations for each constituent. It is expected that the continuous line describing the variation of the coefficient lb/acre-inch with runoff would become asymptotic with the abscissa as runoff increased, such that the total emission (M) of a constituent (lb/acre) would increase at a decreasing rate as runoff magnitude increased. This requirement indicated that the equation selected for the correlation could be of the form $Y = a/(b+\bar{i})$, where Y has units of lb/acre-inch and $Y \cdot \bar{i}$ or M (lb/acre) is the net mass emission per acre per storm of $\bar{i}$ inches runoff. The equations (storm runoff mass emission equations) describing the correlations are as follows (Figures V-21 to V-26):

(1) COD:

$$M_{COD} = \frac{12\bar{i}}{0.01 + \bar{i}} \qquad \text{(V-1)}$$

where: M = mass emission coefficient, lb/acre

$\bar{i}$ = mean runoff due-to-storm

(2) TSS (total suspended solids):

$$M_{TSS} = \frac{24\bar{i}}{0.001 + \bar{i}} \qquad (V\text{-}2)$$

(3) TN (total nitrogen):

$$M_{TN} = \frac{0.60\bar{i}}{0.01 + \bar{i}} \qquad (V\text{-}3)$$

(4) OPP (orthophosphate-phosphorus):

$$M_{OPP} = \frac{0.10\bar{i}}{0.01 + \bar{i}} \qquad (V\text{-}4)$$

(5) HEM (hexane extractable materials):

$$M_{HEM} = \frac{2.1\bar{i}}{0.1 + \bar{i}} \qquad (V\text{-}5)$$

(6) Floatable materials:

$$M_{FM} = \frac{0.24\bar{i}}{0.01 + \bar{i}} \qquad (V\text{-}6)$$

Discussion of Storm Runoff Mass Emission Equations

The storm runoff mass emission equations described by Equations V-1 to V-6 provide several significant insights to the problems associated with quantifying and evaluating the pollution contribution of storm runoff. These equations are the first quantitative attempts to describe the variation on a normalized basis of storm runoff pollutant loads over a range of runoff conditions. Previous efforts to establish mass emission coefficients have been directed to evaluation of flow-weighted mean coefficients (units of lb/acre-inch or mg/l) on the basis of overall runoff (References V-1 and V-3). The equations have been used to estimate the pollutant emissions as a function of storm runoff per 1,000 acre area (Figure V-29), from which it is apparent that for a given mean runoff due-to-storm, the mass contribution of TSS is expected to be from two to

2-1/2 times the COD contribution, and that the mass contributions of total nitrogen and orthophosphate-phosphorus are expected to be about five percent and one percent of the COD contributions, respectively. The mass contribution of HEM is expected to be about five percent of the COD contribution, and floatable materials emission from one to two percent of the COD emissions. These relative findings are consistent with the findings of previous studies at San Francisco (Reference V-1) and Cincinnati (Reference V-3).

The second ramification of Equations V-1 to V-6 is that they permit the estimation of pollutant quantities on a per storm basis rather than on an annual runoff basis. Given the duration and magnitude of a storm, a runoff coefficient for the basin, the storm runoff mass emission equations, and dry weather flow and mass emission coefficients for a basin, it becomes possible to estimate the pollutant load in the combined sewage flow due to storm runoff as well as to dry weather flow. The key advantage of the per storm approach is that, given an annual pattern of rainfall (defined by rainfall magnitude and time intervals between rainfalls), estimates can then be made of the rate and magnitude of combined sewage flows and pollutant emissions both on an individual storm basis as well as over a wet weather season. From an engineering standpoint, this capability allows the engineer to quantify wastewater flow and loads for a diversity of rainfall histories and to consider the efficacy of alternative schemes for treatment and/or retention. The ramifications of this capability are presented and discussed in Chapter VII.

A final consideration evolving from the storm runoff mass emission equations is that the generalized multibasin approach used in this study, as well as the rainfall intensities observed in the monitored storms, precluded the development of an information base for relating mass emissions due to storms with basin-specific characteristics such as numbers of catch basins, cleaning frequency of streets, land quality, etc. The random nature of the data in the data sets developed for each constituent is strong evidence that, regardless of the effects of system storage, land use and topography, etc., the aggregate parameter

of lb/acre-inch as related to runoff due-to-storm can be used to describe pollutant emissions from all of the basins considered in this and the previous San Francisco studies (Reference V-1).

CHAPTER V - LIST OF REFERENCES

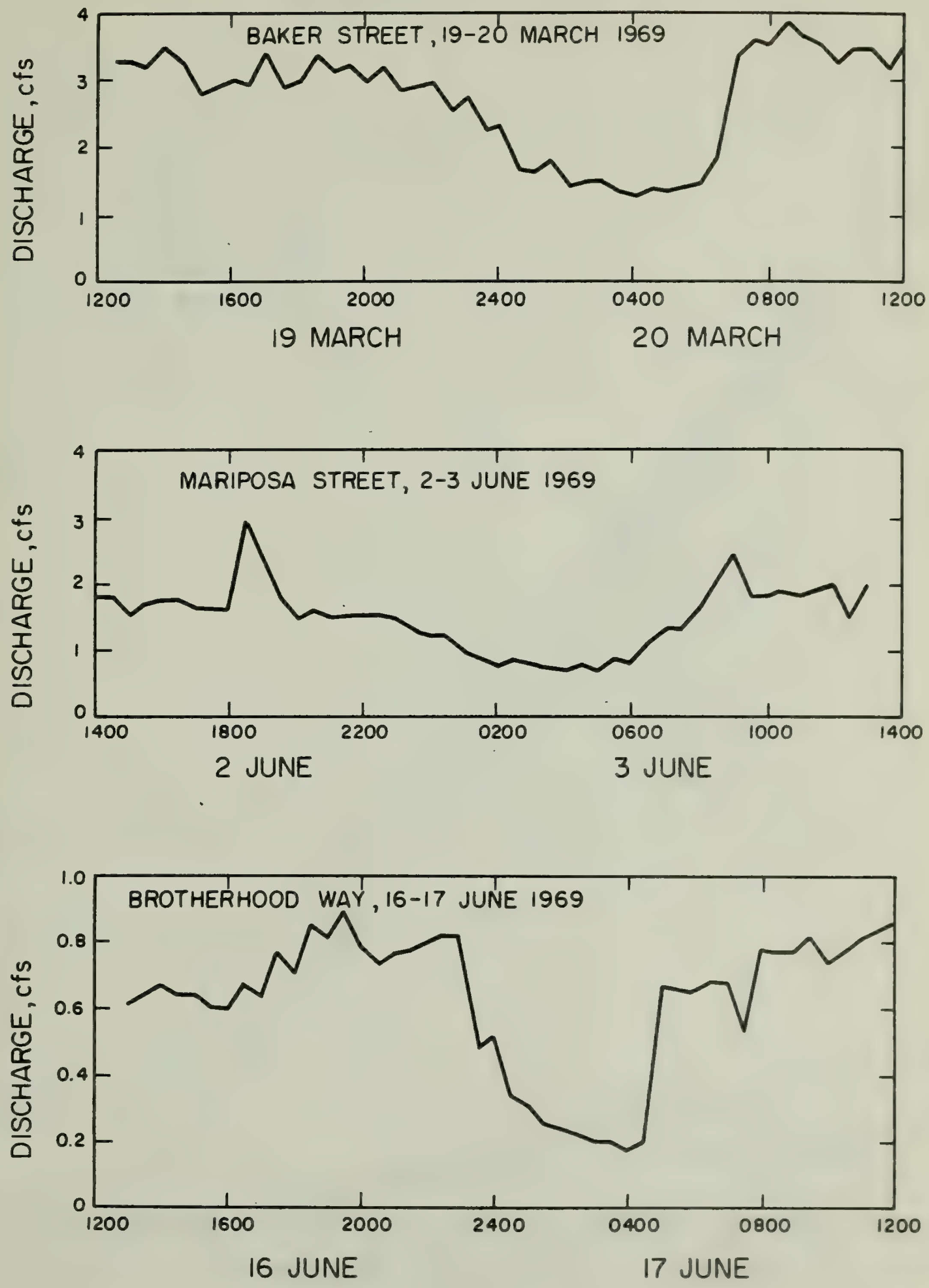
V-1 *"Characterization and Treatment of Combined Sewer Overflows"*, report to City and County of San Francisco, by Engineering-Science, Inc., November 1967.

V-2 Personal communication, R.T. Cockburn, City and County of San Francisco, August 1969.

V-3 Anderson, R.J., Weibel, S.R., and Woodward, R.L., *"Urban Land Runoff as à Factor in Stream Pollution"*, Jour. Water Pollution Control Federation, 36 (7), 914, July 1964.

V-4 *"Water Pollution Aspects of Urban Runoff"*, by American Public Works Association, WP-20-15, Water Pollution Control Research Series, United States Department of the Interior, Federal Water Pollution Control Administration, January 1969.

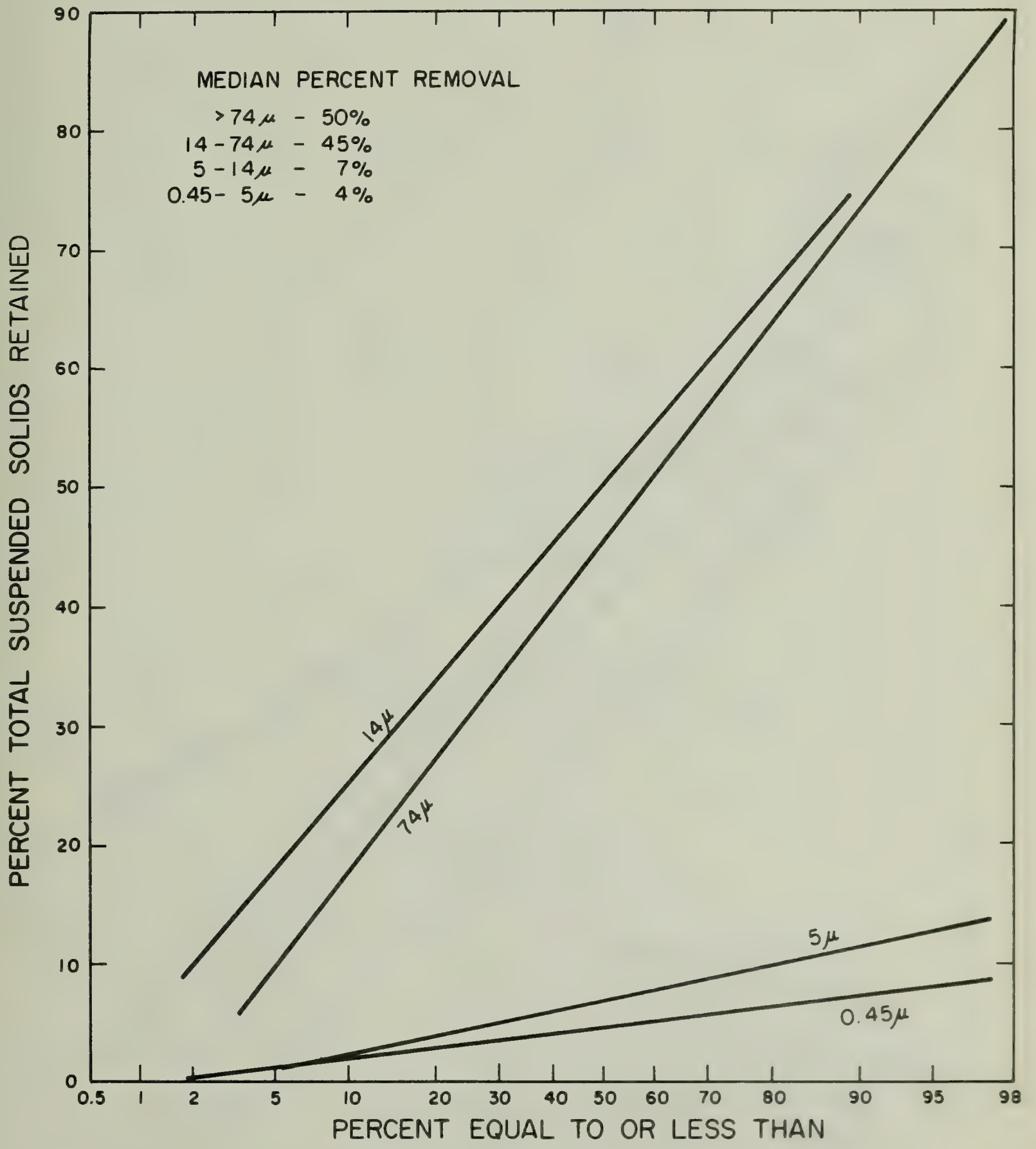
FIGURE V-1



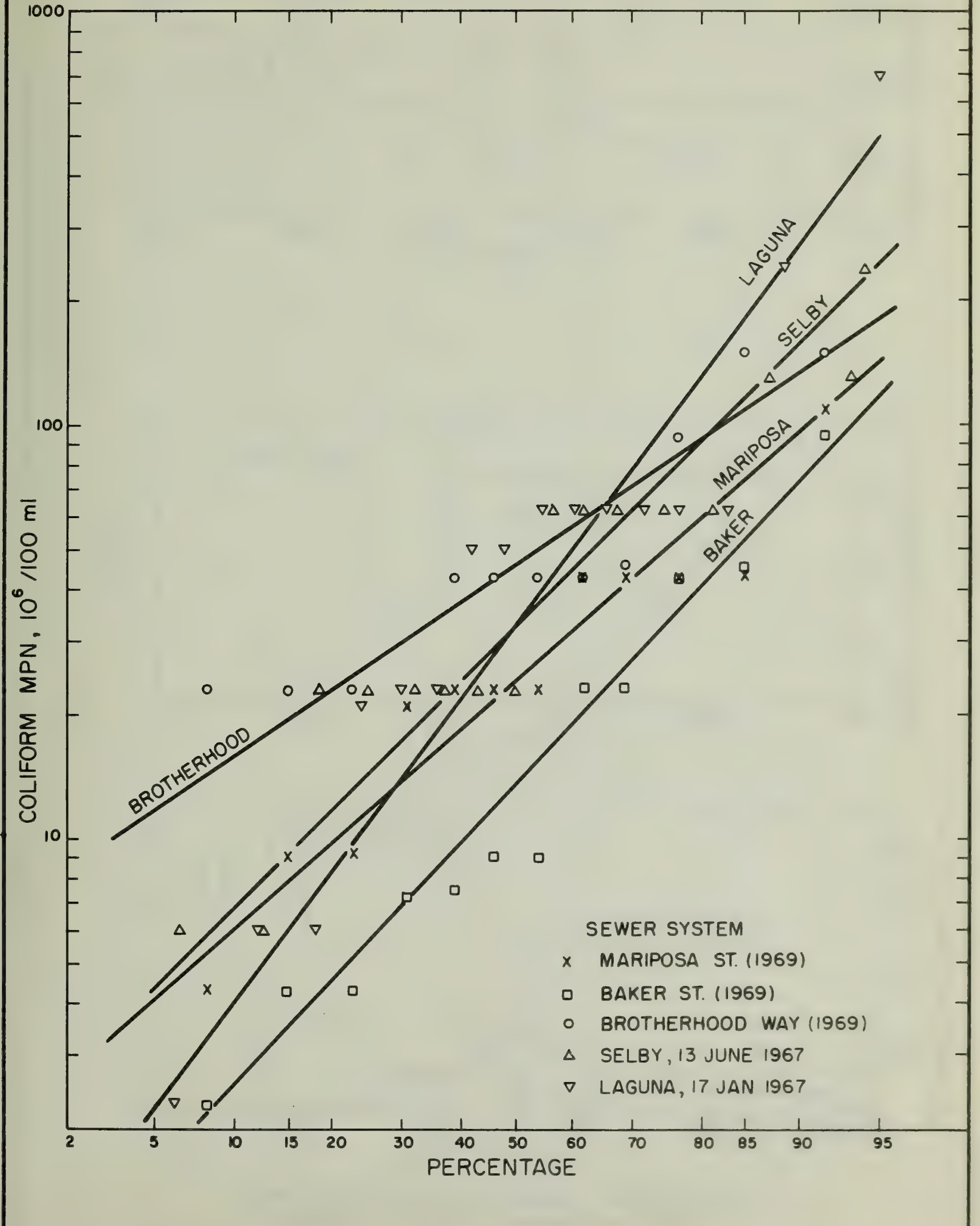
DRY WEATHER FLOWS FOR COMBINED SEWERS

FIGURE V-2

DISTRIBUTION OF PERCENT TOTAL SUSPENDED SOLIDS REMOVED ON 74, 14, 5 AND 0.45 μ SEQUENTIAL FILTERS
DRY WEATHER FLOWS

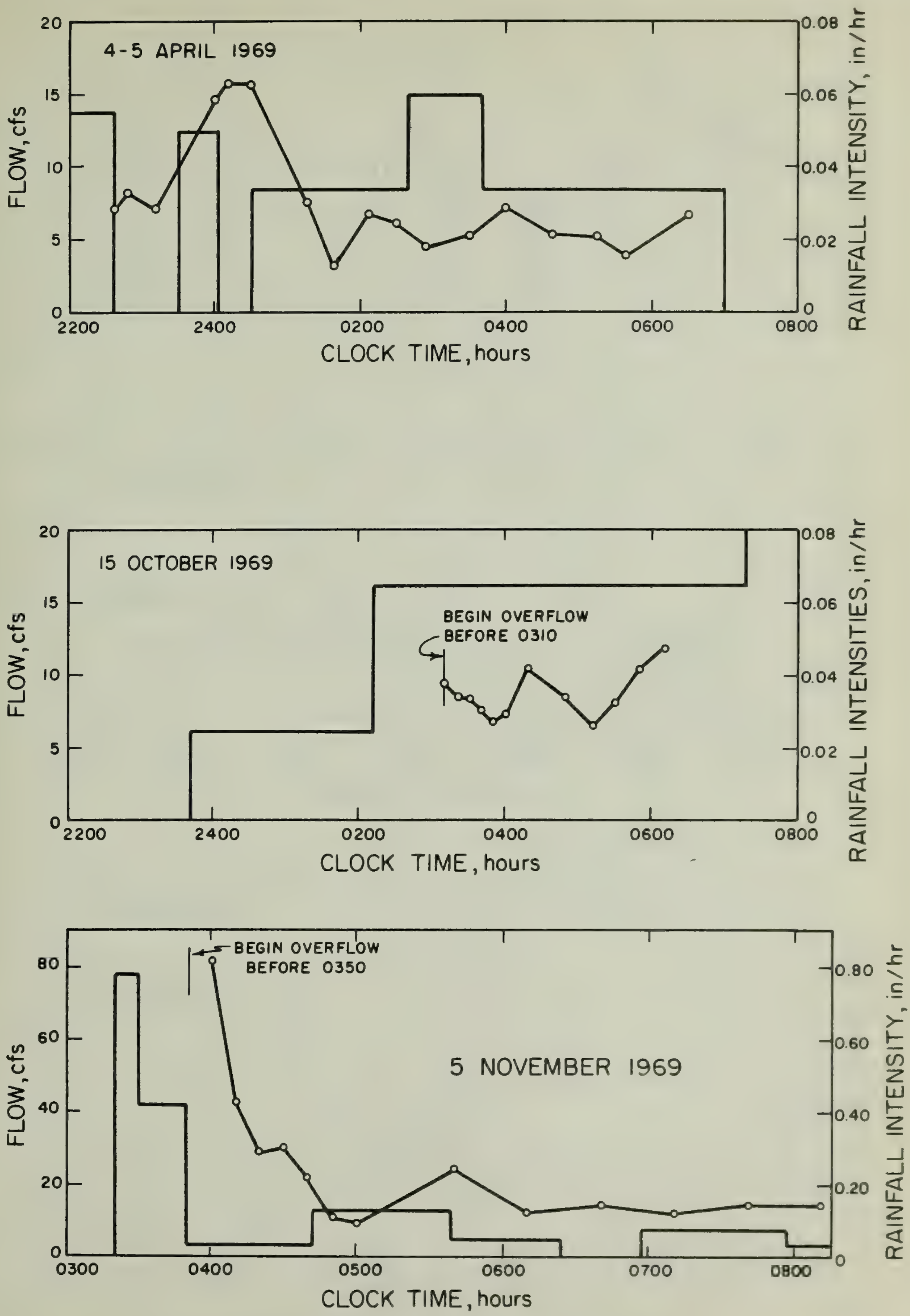


COLIFORM MPN DATA, DRY WEATHER FLOWS



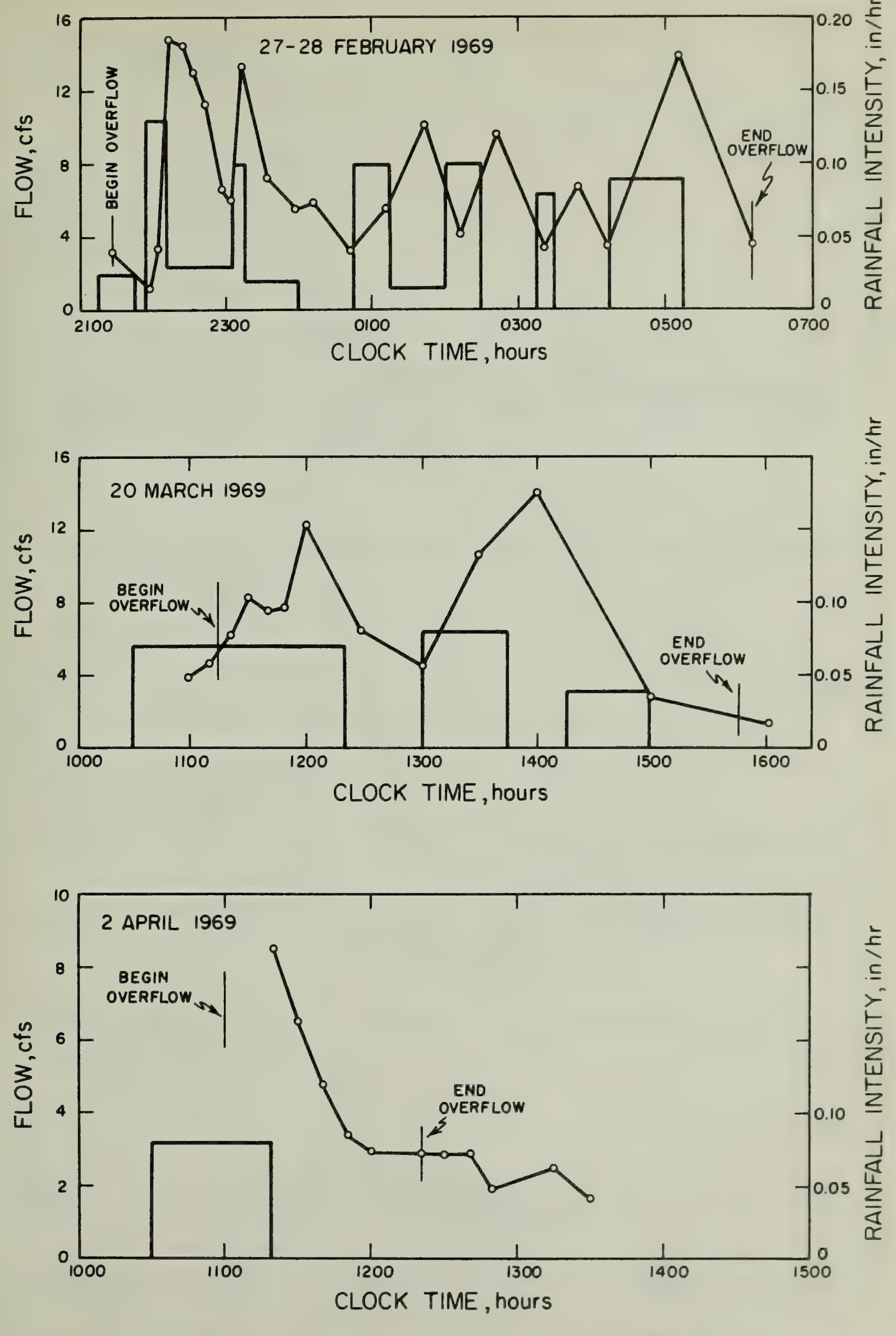
ENGINEERING-SCIENCE, INC.

FIGURE V-4



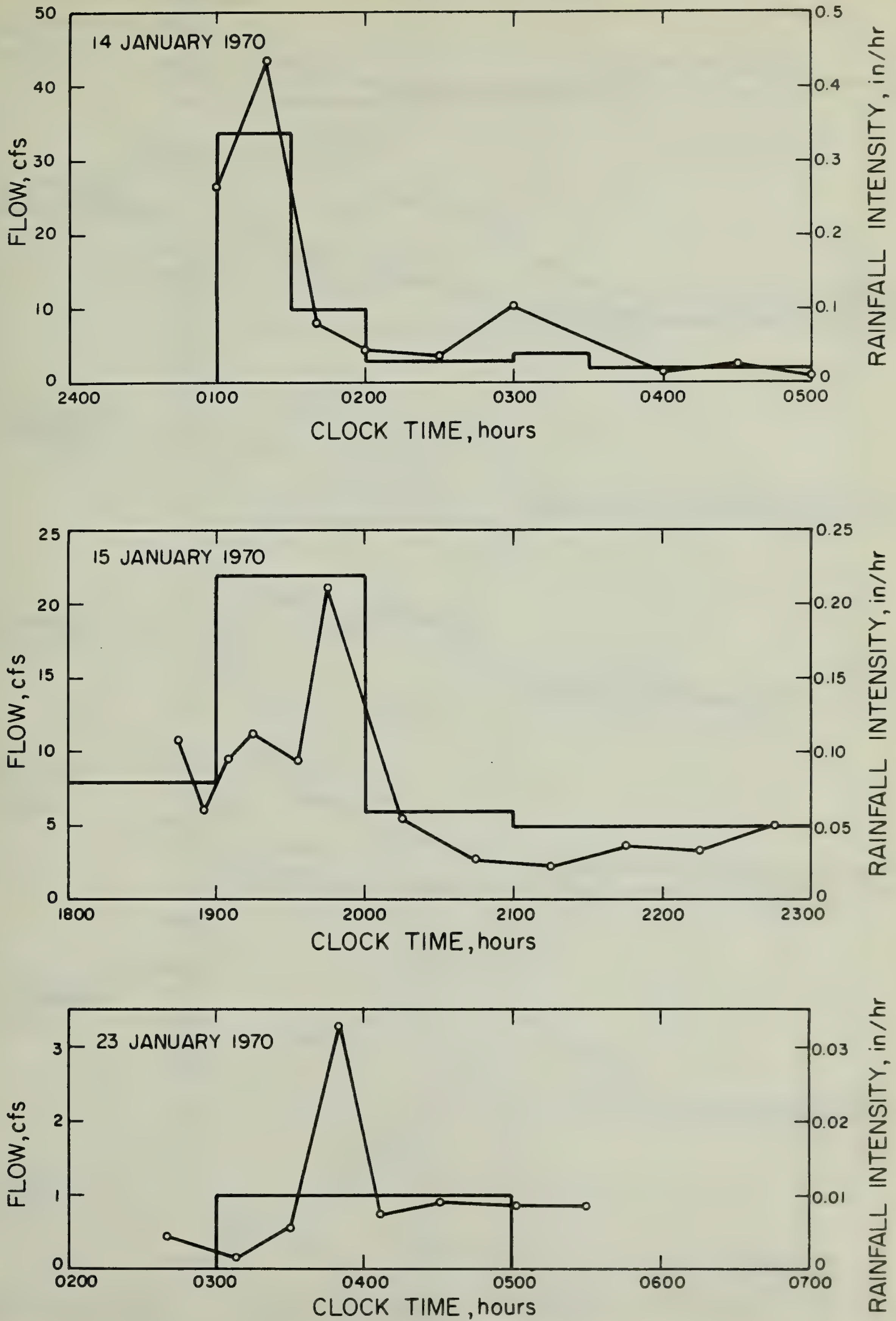
FLOW RATE AND RAINFALL INTENSITY
BAKER STREET SAMPLING SITE

FIGURE V-5

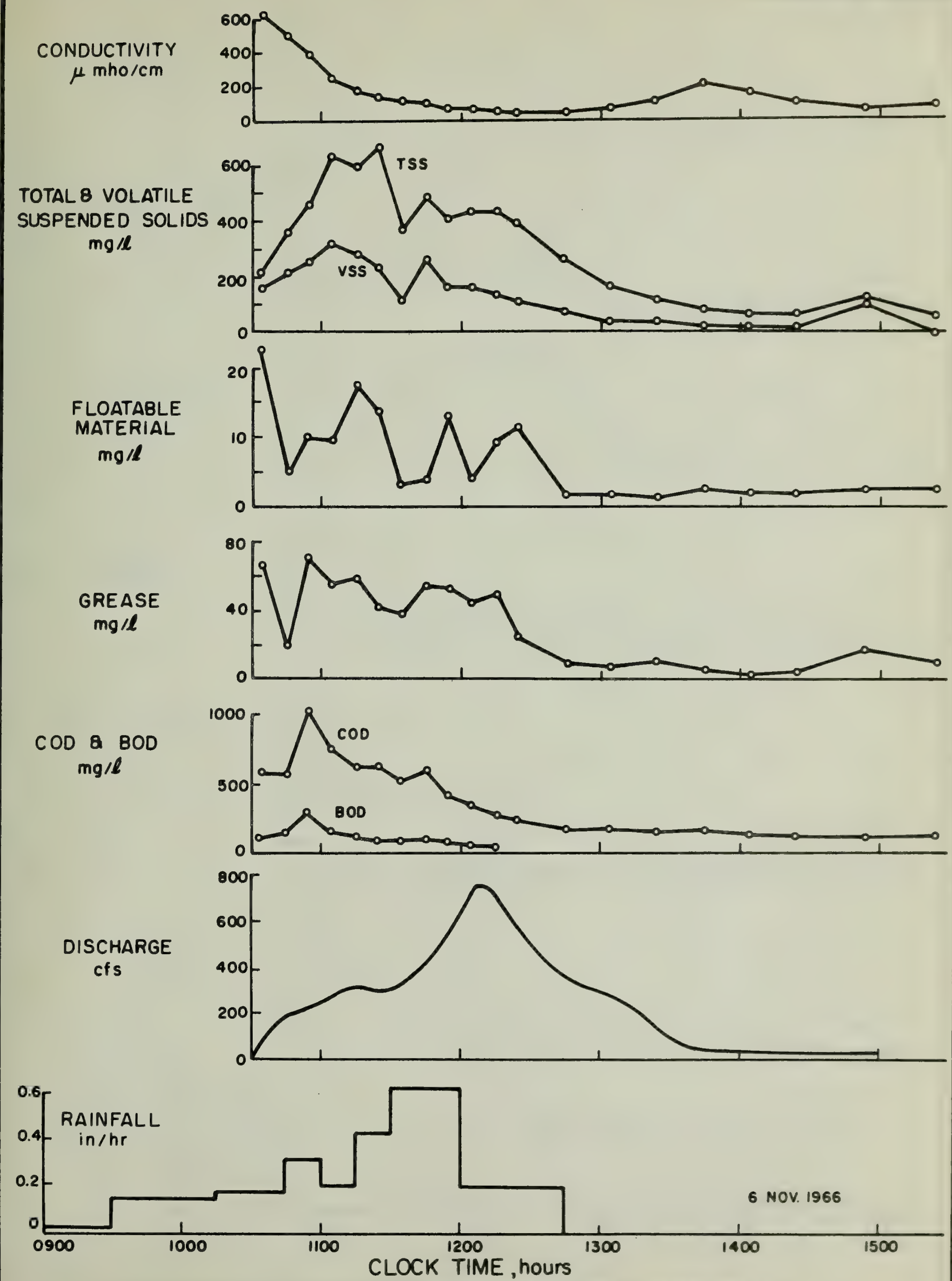


FLOW RATE AND RAINFALL INTENSITY
MARIPOSA STREET SAMPLING SITE

FIGURE V-6

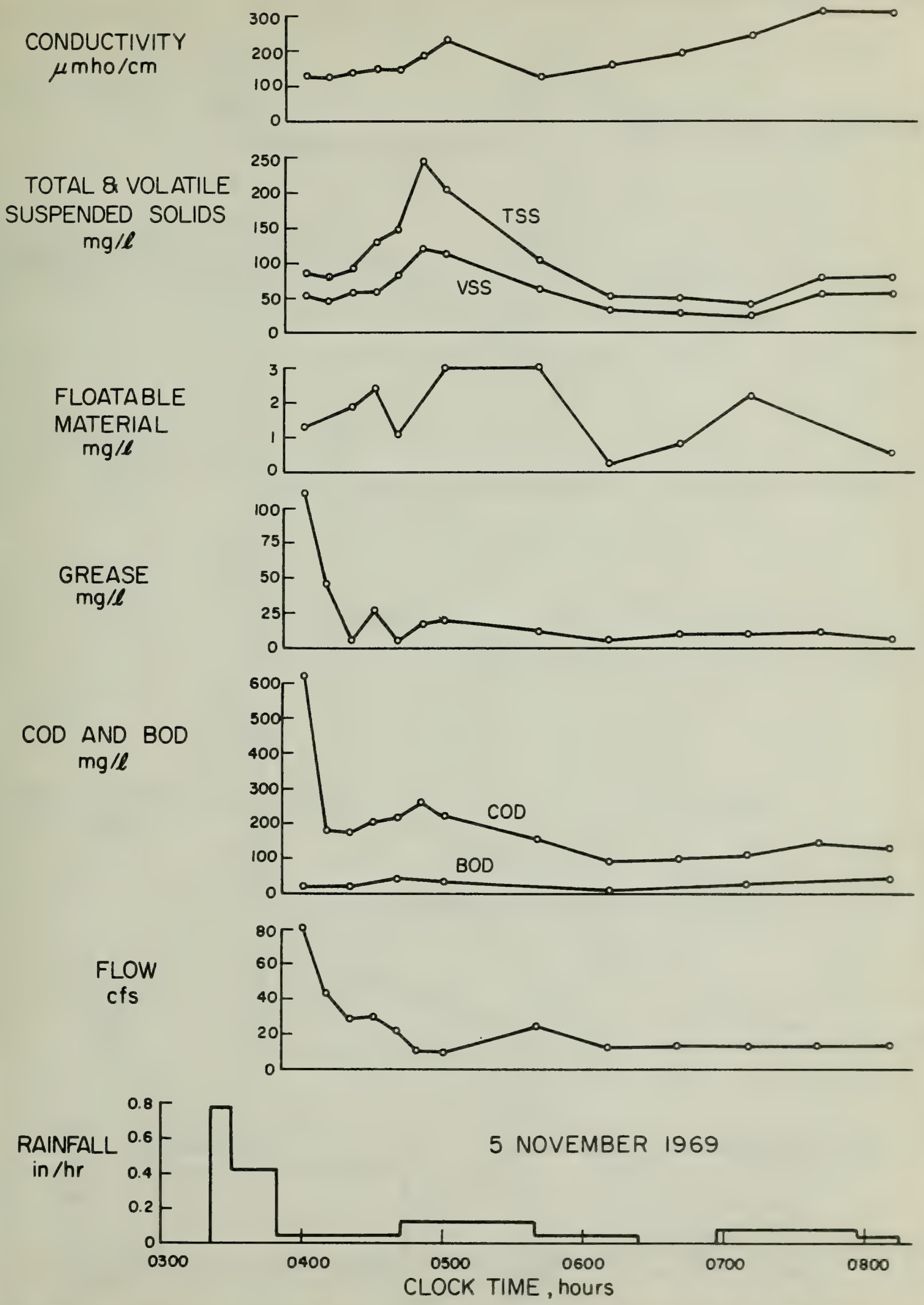


FLOW RATE AND RAINFALL INTENSITY
BROTHERHOOD WAY SAMPLING SITE

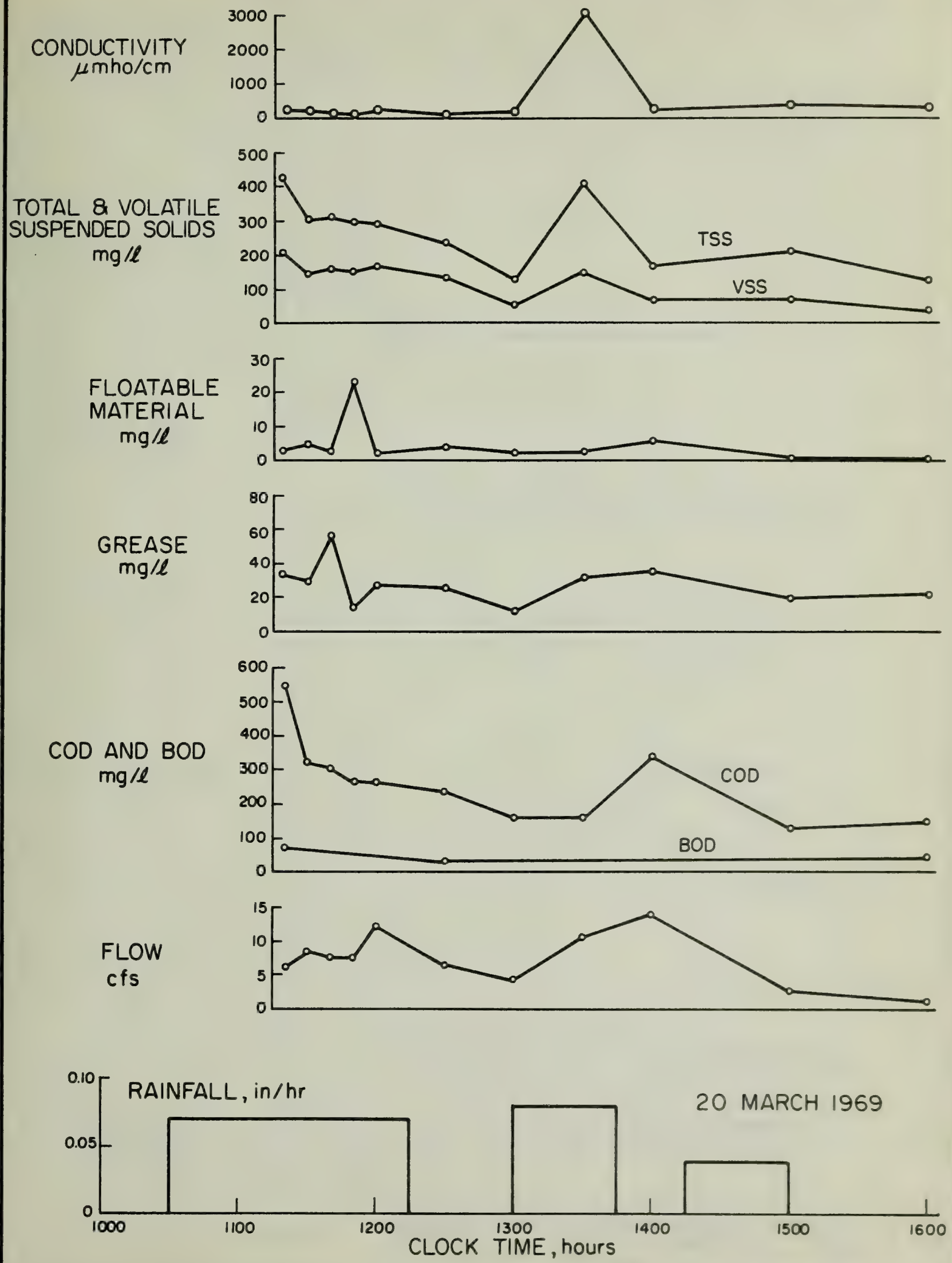


CHARACTERISTICS OF RAINFALL AND COMBINED SEWER OVERFLOW, SELBY STREET

FIGURE V-8

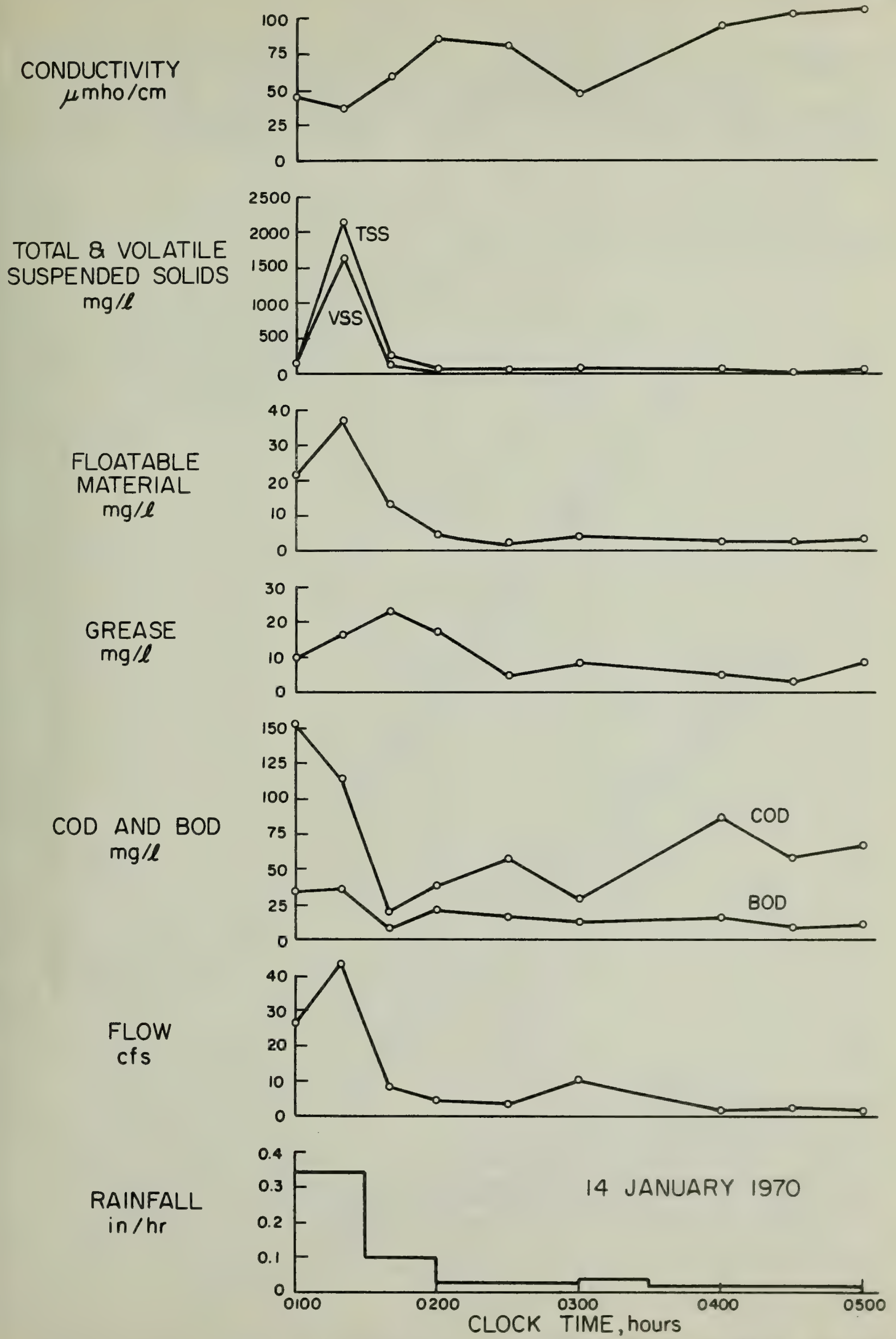


CHARACTERISTICS OF RAINFALL AND COMBINED SEWER OVERFLOW
BAKER STREET SAMPLING SITE



CHARACTERISTICS OF RAINFALL AND COMBINED SEWER OVERFLOW
MARIPOSA STREET SAMPLING SITE

ENGINEERING–SCIENCE, INC.



CHARACTERISTICS OF RAINFALL AND COMBINED SEWER OVERFLOW
BROTHERHOOD WAY SAMPLING SITE

DISTRIBUTION OF PERCENT TOTAL SUSPENDED SOLIDS REMOVED ON 74, 14, 5 AND 0.45μ SEQUENTIAL FILTERS WET WEATHER FLOWS - BAKER STREET, MARIPOSA STREET

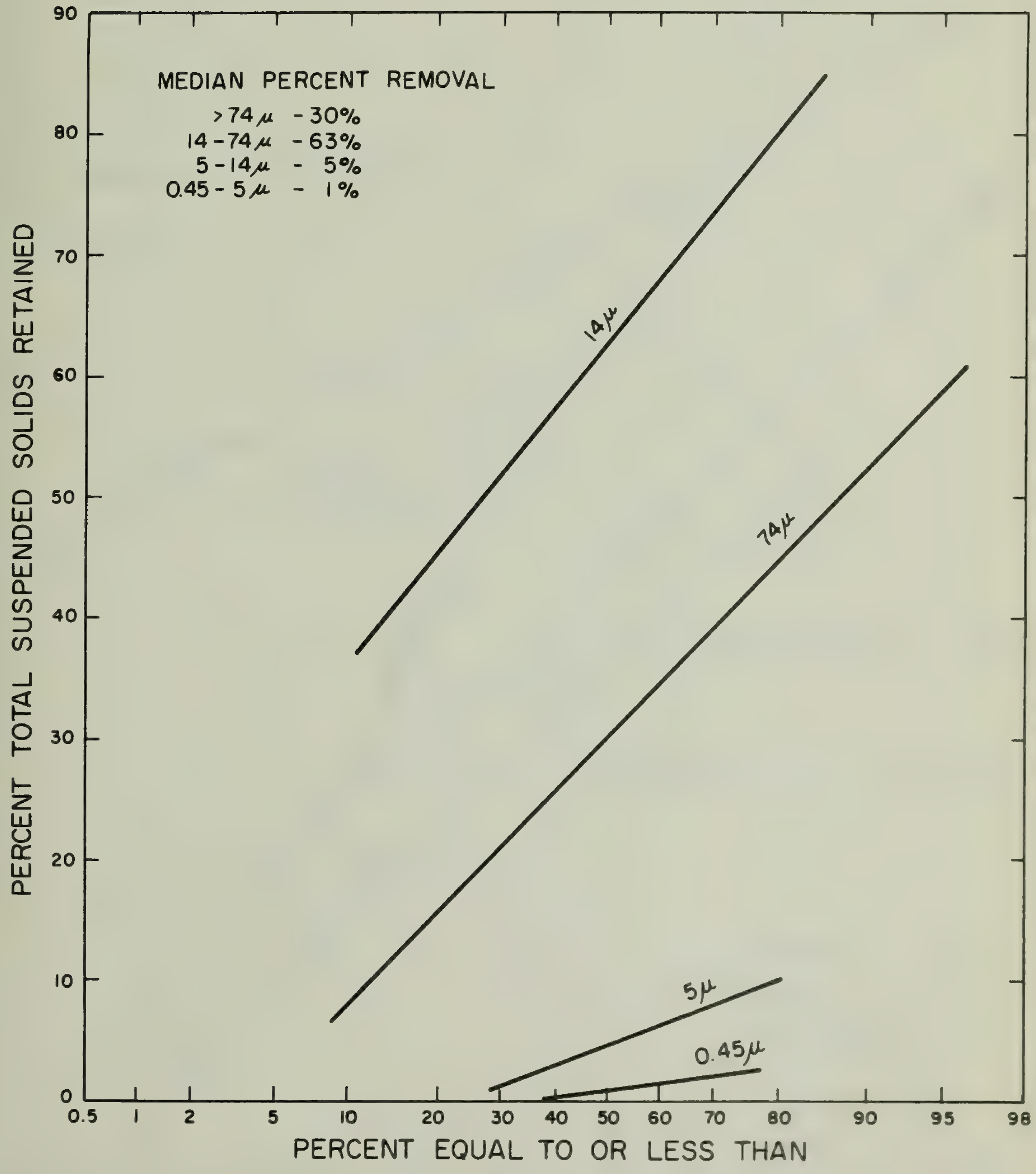


FIGURE V-12

COMBINED SEWAGE COLIFORM MPN DATA
BAKER AND MARIPOSA STREET AND BROTHERHOOD WAY SEWERS

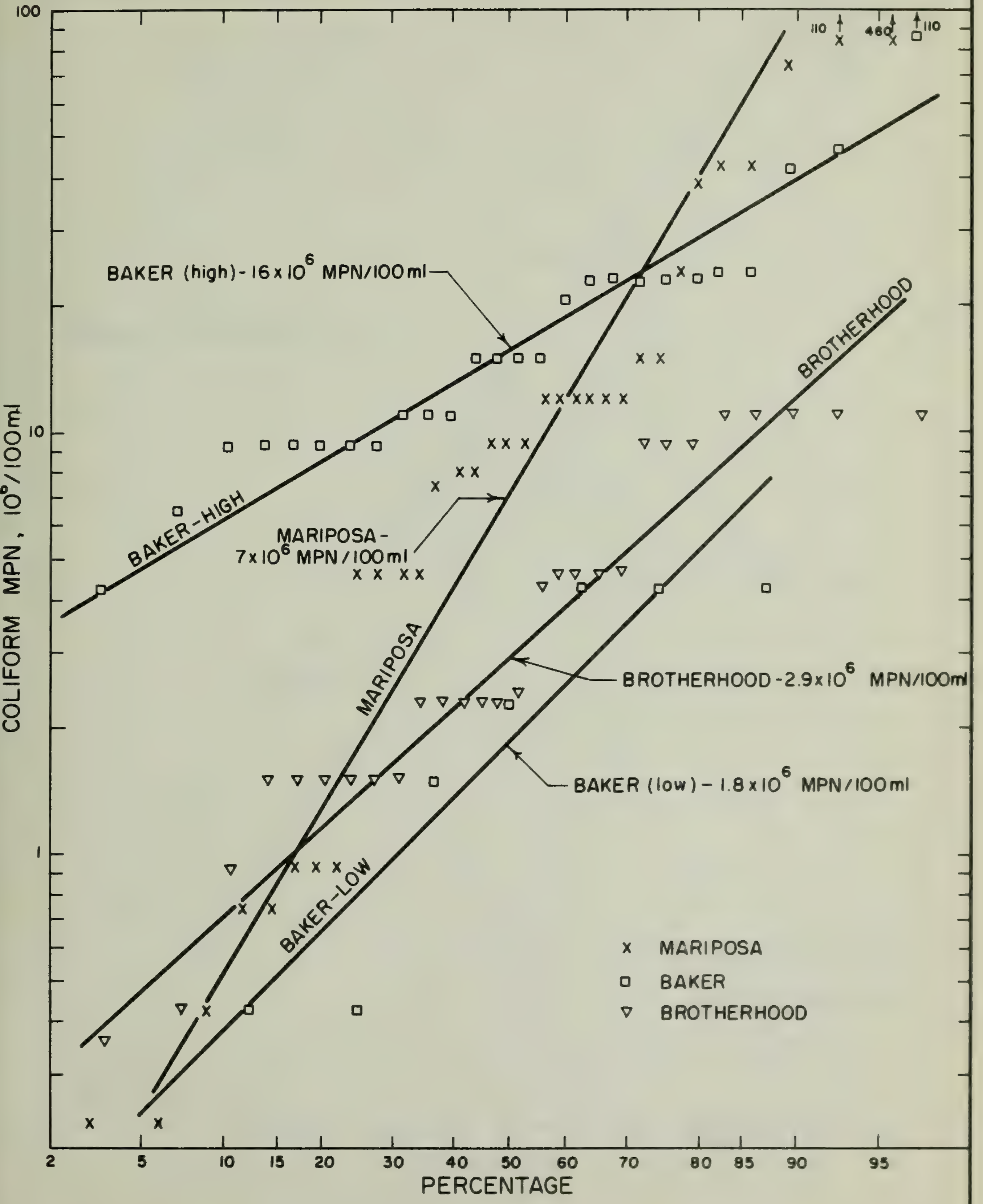
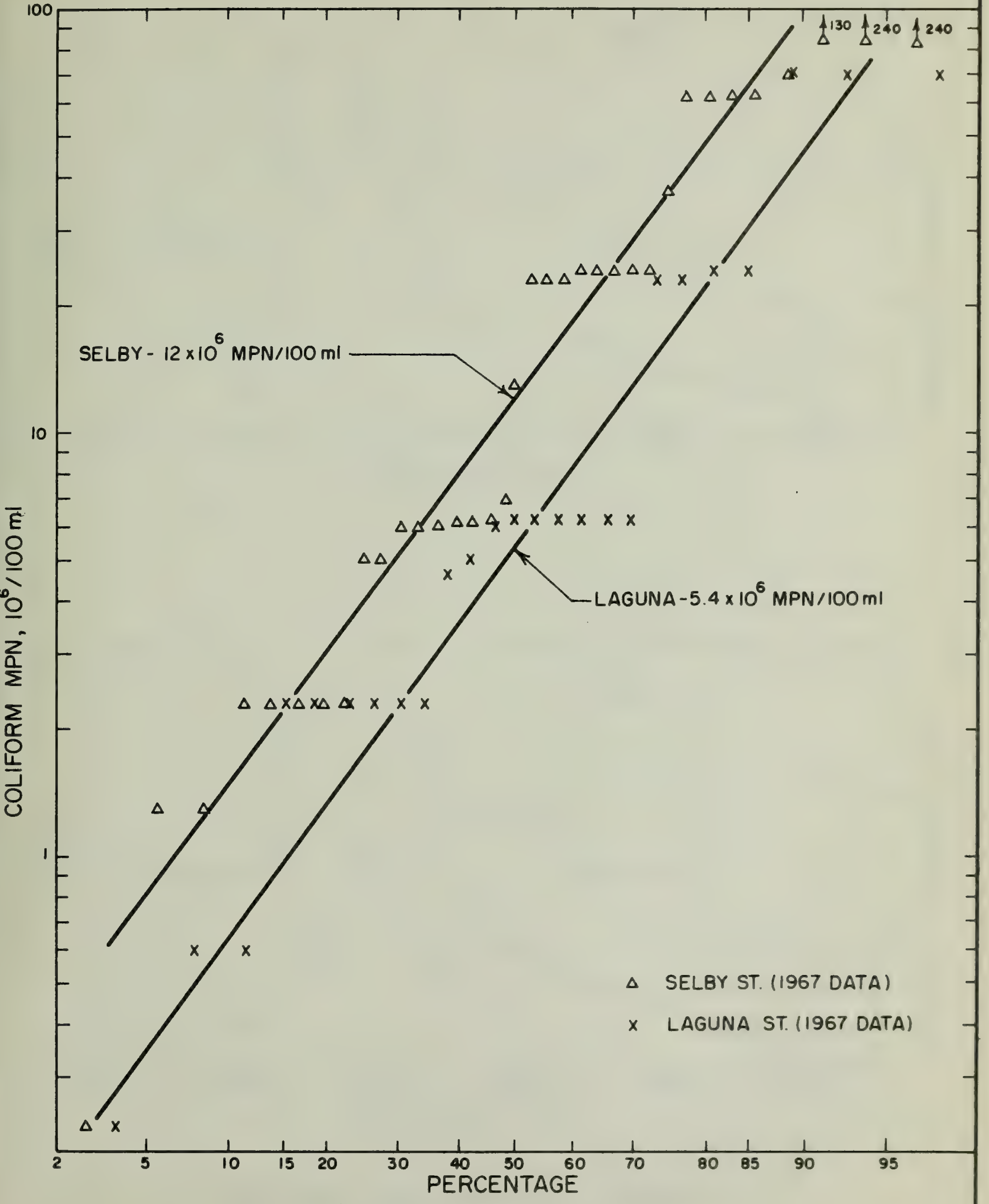
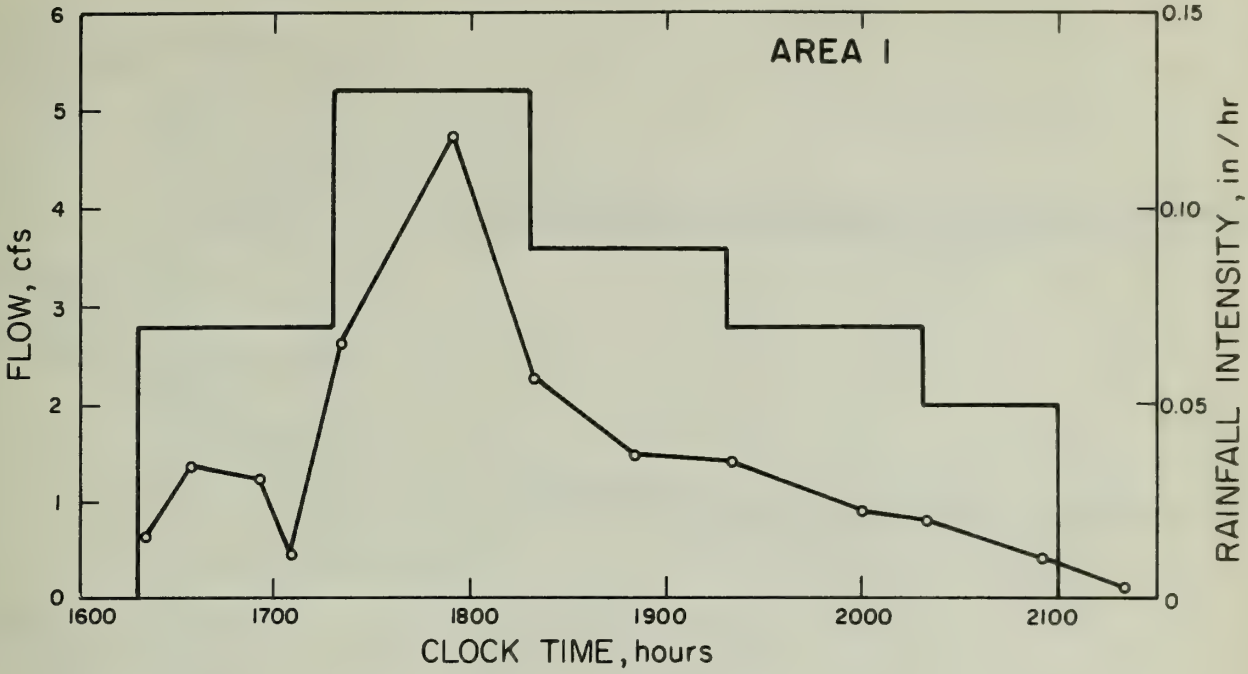
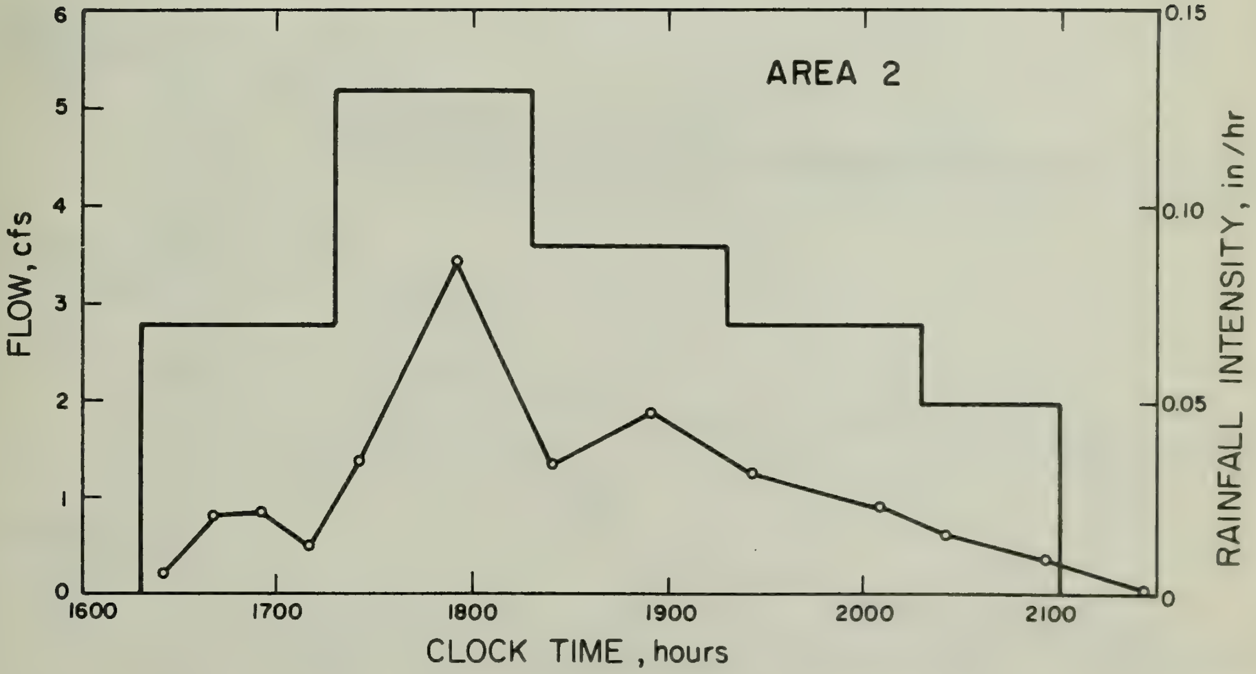


FIGURE V-13

COMBINED SEWAGE COLIFORM MPN DATA
SELBY AND LAGUNA STREET SEWERS



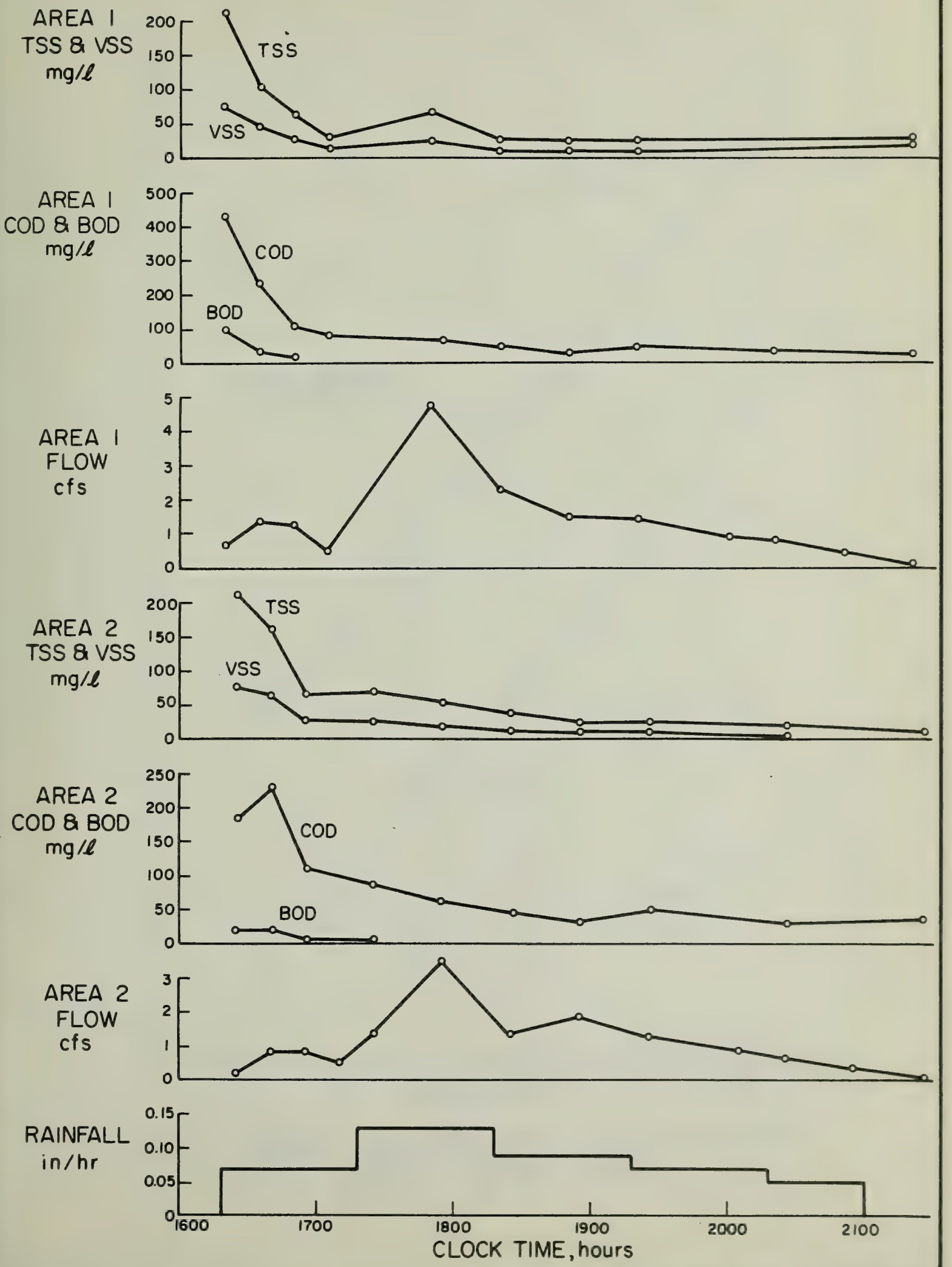




FLOW RATE AND RAINFALL INTENSITY
VICENTE STREET SAMPLING SITE
16 FEBRUARY 1970

FIGURE V-15

CHARACTERISTICS OF RAINFALL AND STORM SEWER FLOW VICENTE STREET SAMPLING SITES



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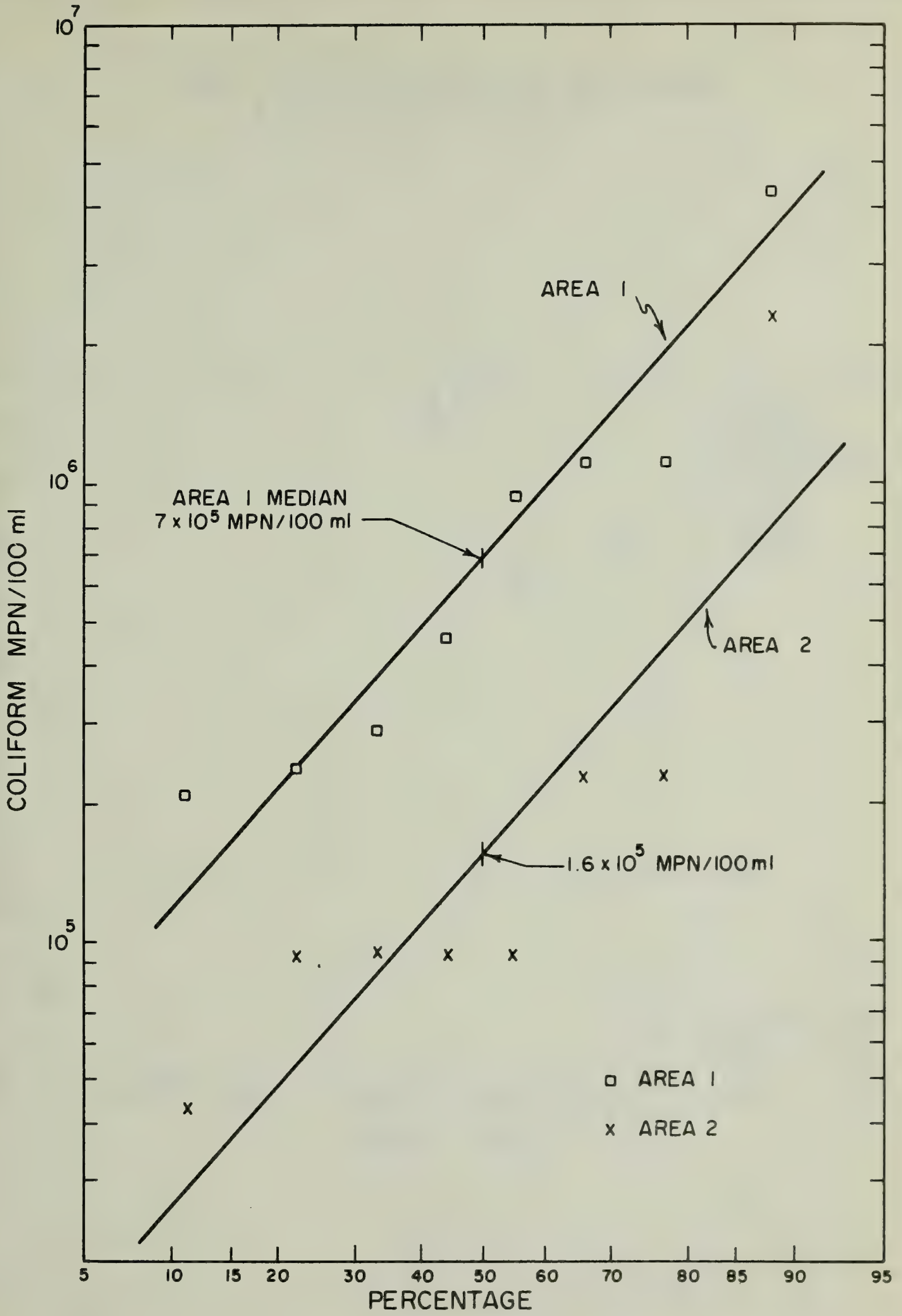
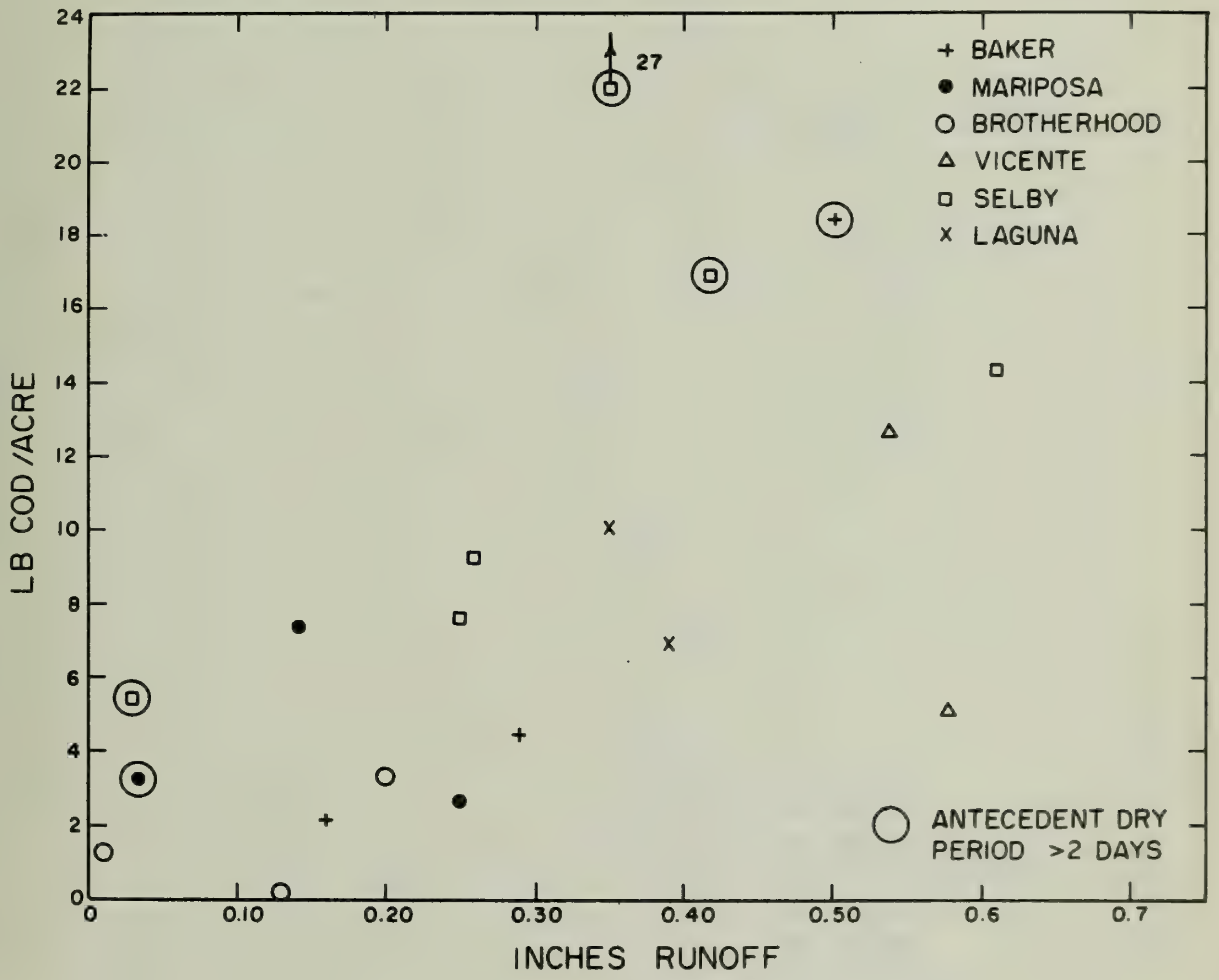


STORM SEWAGE COLIFORM MPN CONCENTRATIONS
VICENTE STREET DRAINAGE BASIN
AREAS 1 AND 2

COD-NET EMISSION/ACRE VS RUNOFF
(RECTILINEAR SCALE)



COD-NET EMISSION PER ACRE VS RUNOFF (SEMILOG SCALE)

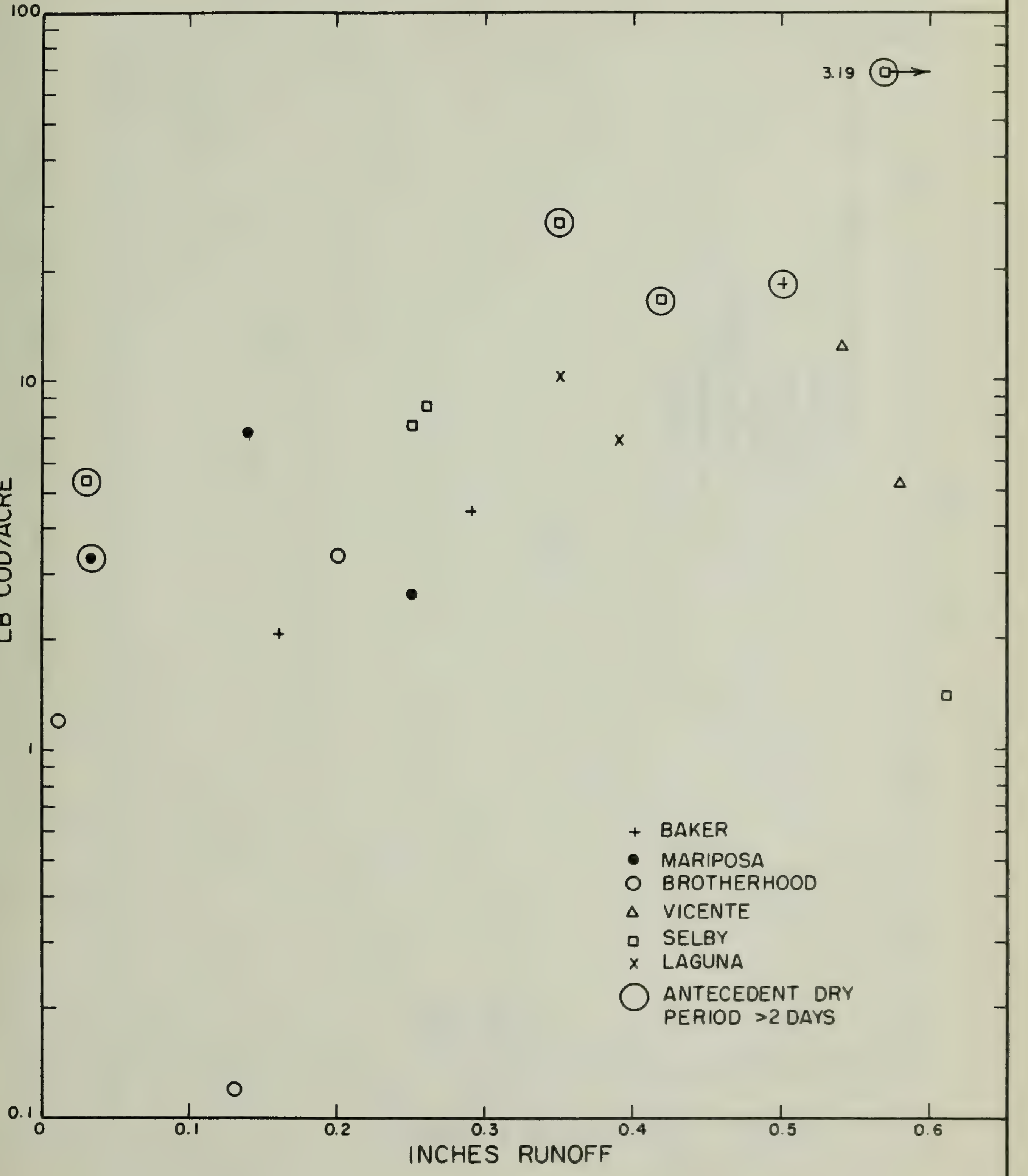
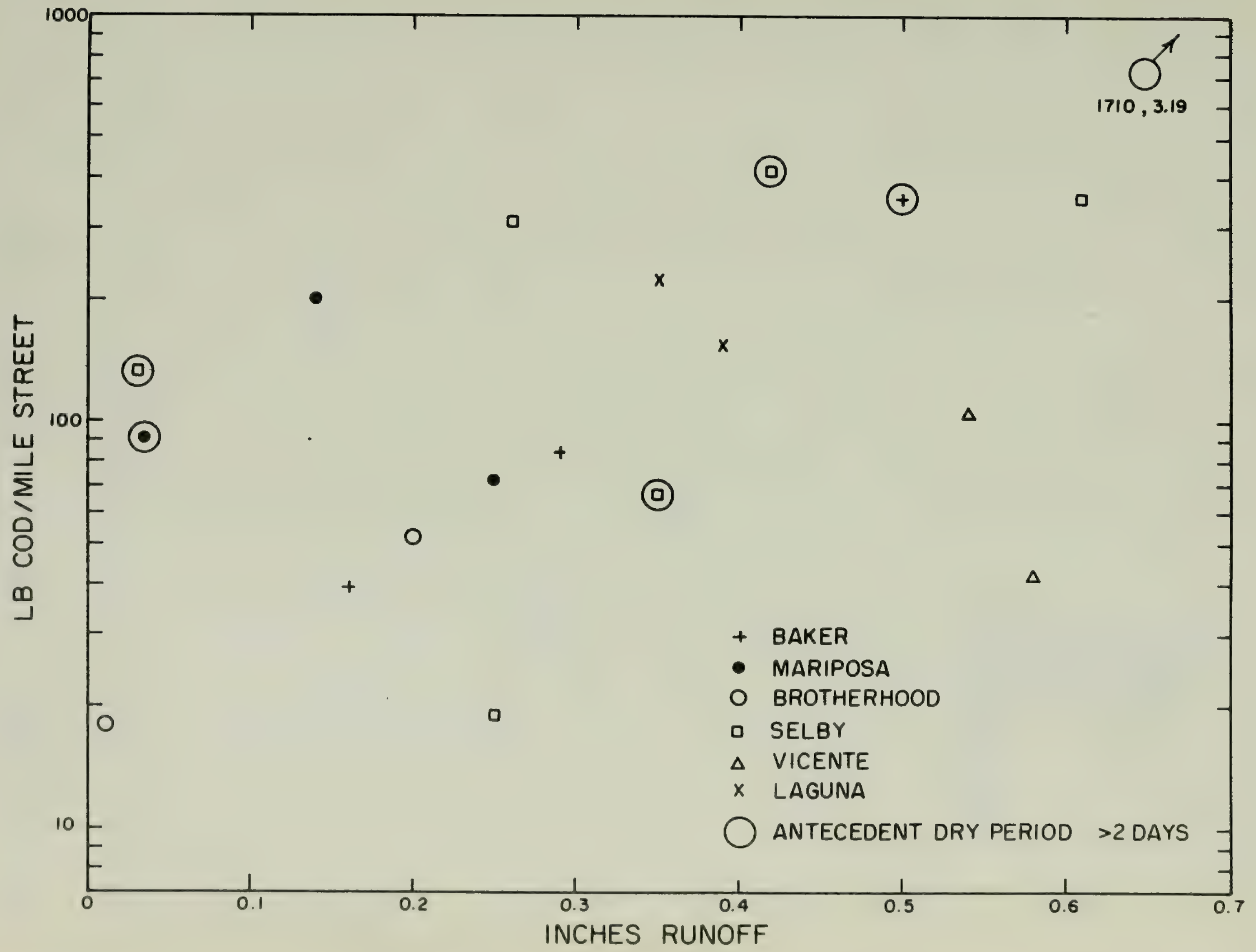
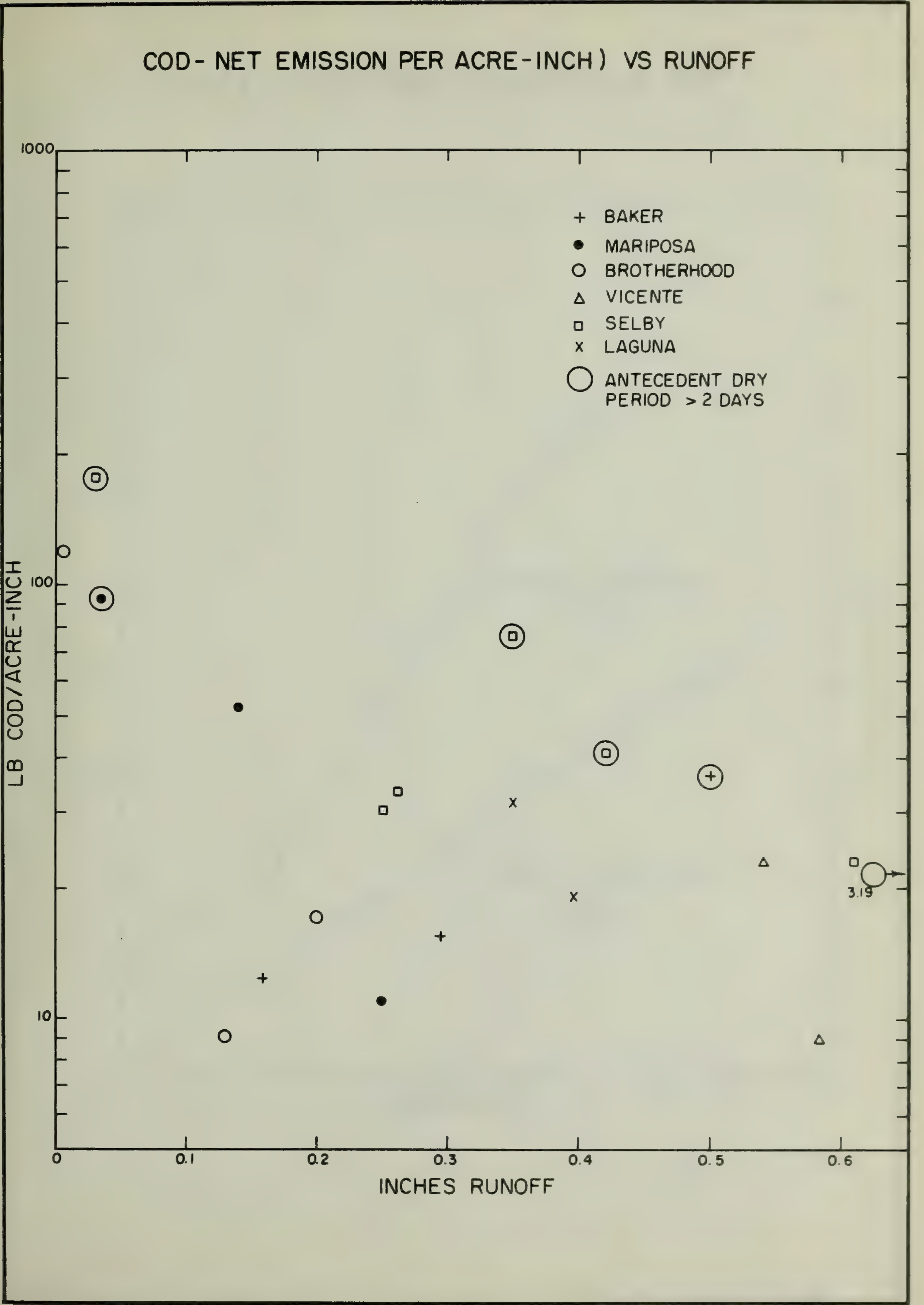


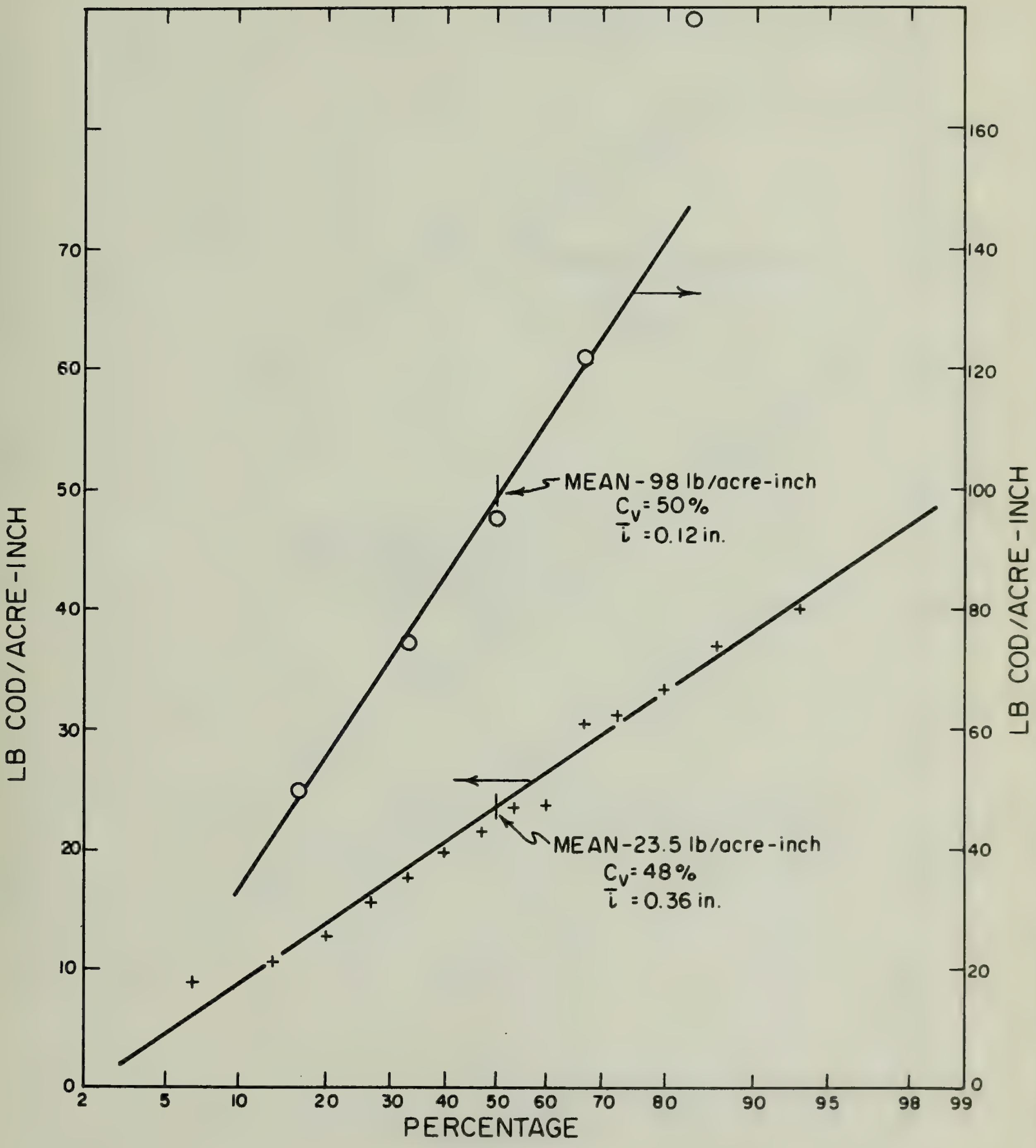
FIGURE V-19

COD-NET EMISSION PER MILE STREET VS RUNOFF

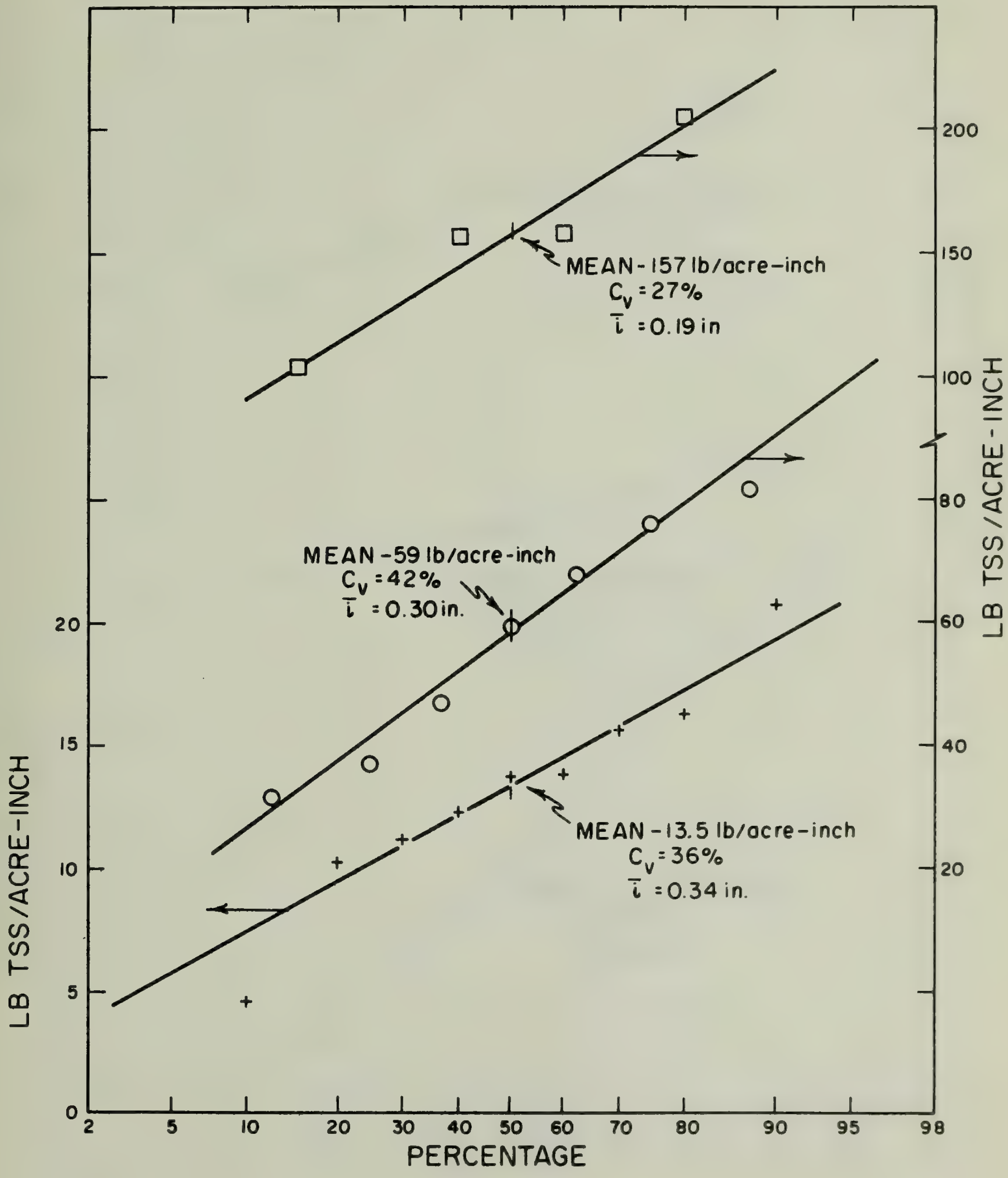



COD- NET EMISSION PER ACRE-INCH) VS RUNOFF
LB COD/ACRE-INCH
1000
100
10
INCHES RUNOFF
0
0.1
0.2
0.3
0.4
0.5
0.6
+ BAKER
● MARIPOSA
O BROTHERHOOD
Δ VICENTE
□ SELBY
x LAGUNA
◯ ANTECEDENT DRY PERIOD > 2 DAYS
3.19

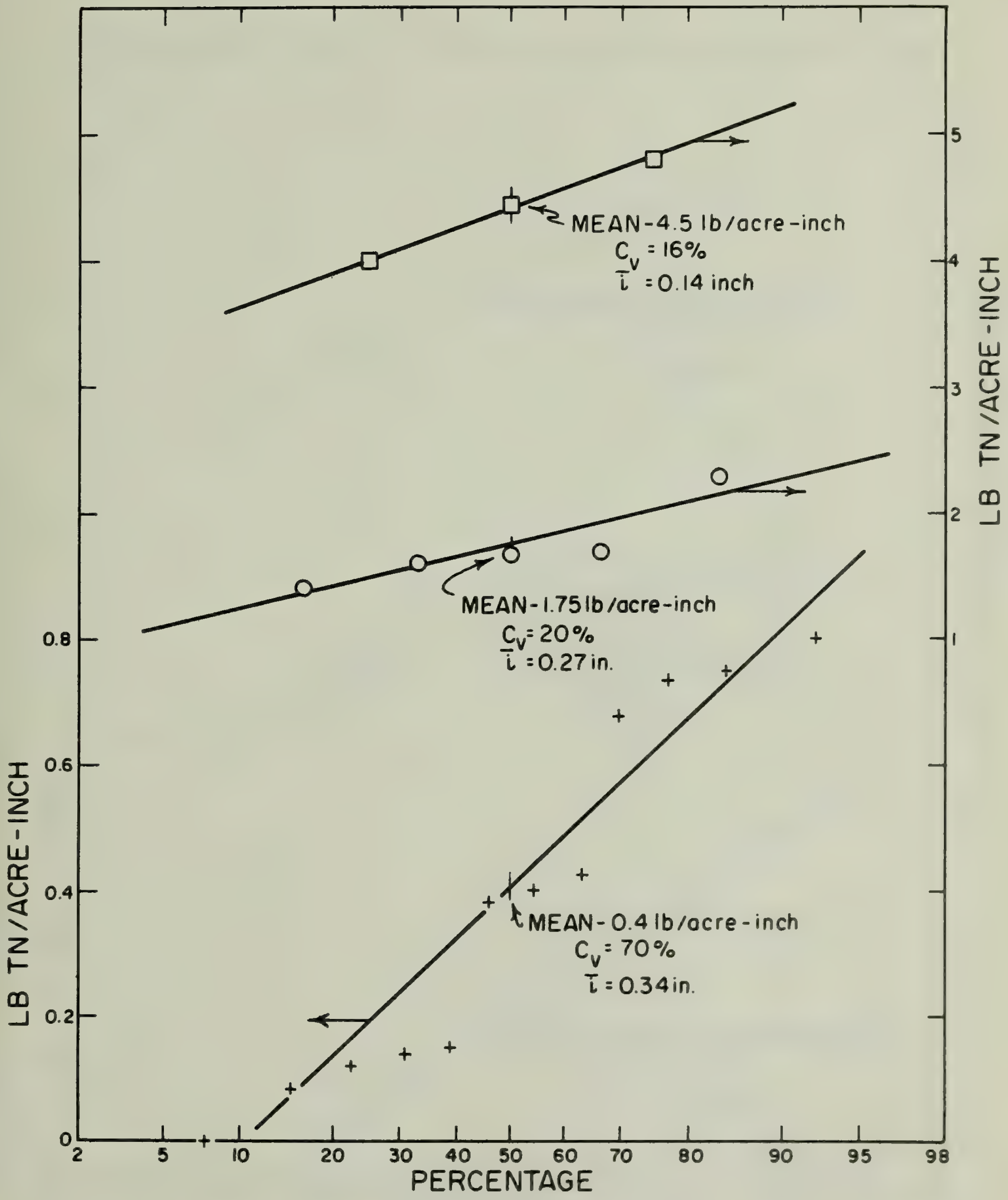
COD (NET LB/ACRE-INCH) DATA DISTRIBUTION



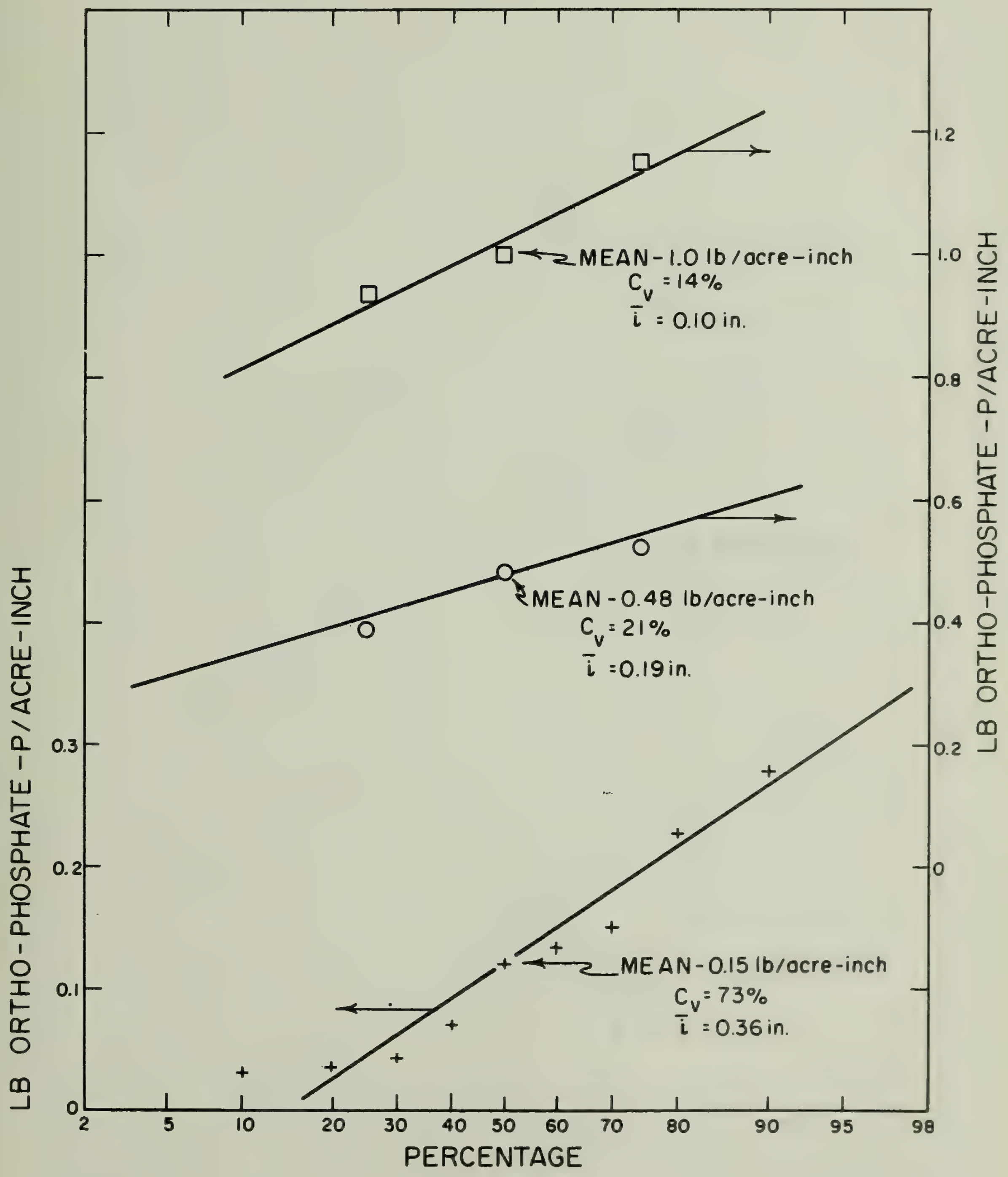
TOTAL SUSPENDED SOLIDS (NET LB/ACRE-INCH) DATA DISTRIBUTION



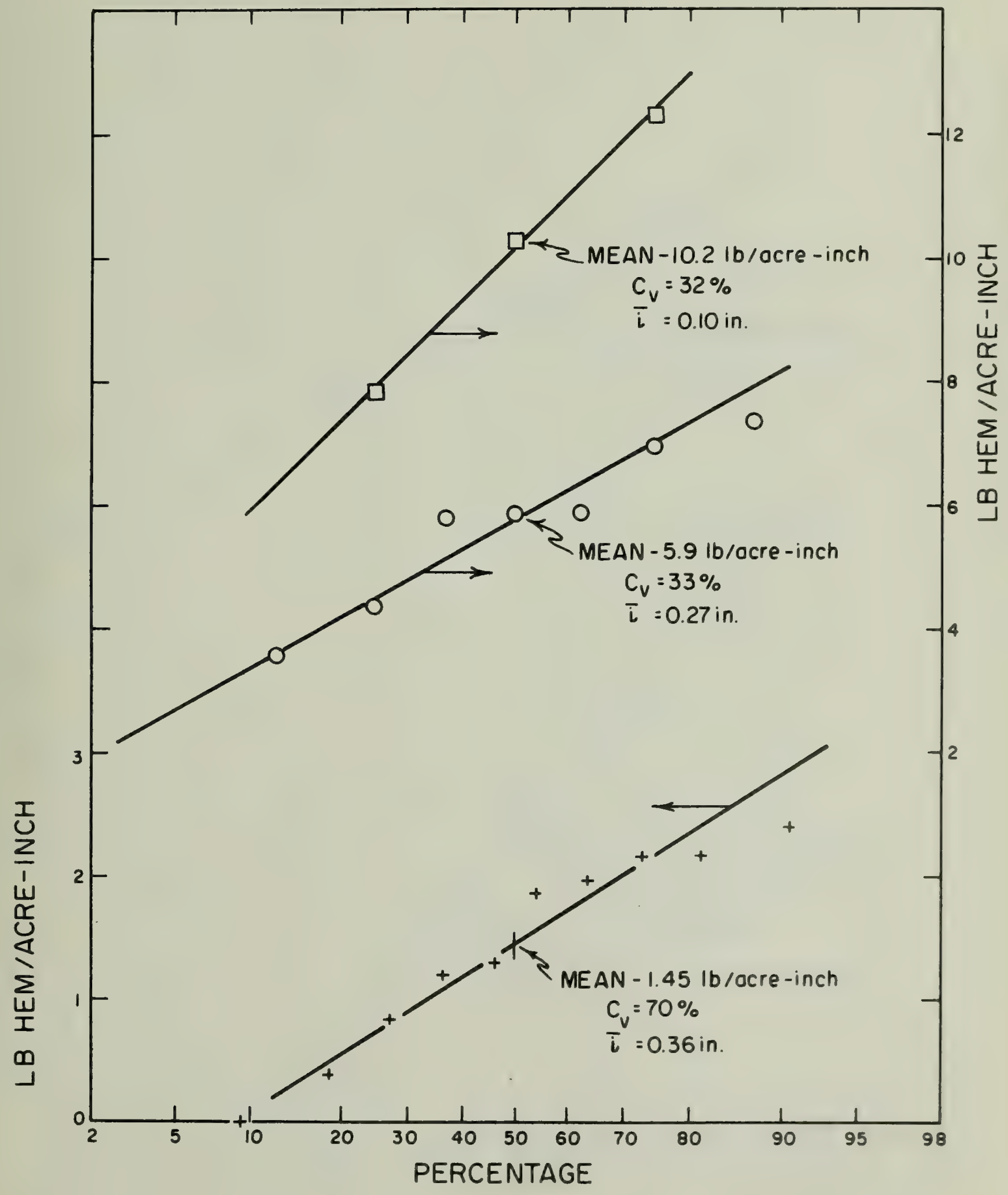
TOTAL NITROGEN (NET LB/ACRE-INCH) DATA DISTRIBUTION



ORTHO-PHOSPHATE-PHOSPHORUS (NET LB/ACRE-INCH) DATA DISTRIBUTION



HEXANE EXTRACTABLE MATERIALS (LB/ACRE-INCH) DATA DISTRIBUTION



FLOATABLE MATERIALS (LB/ACRE-INCH) DATA DISTRIBUTION

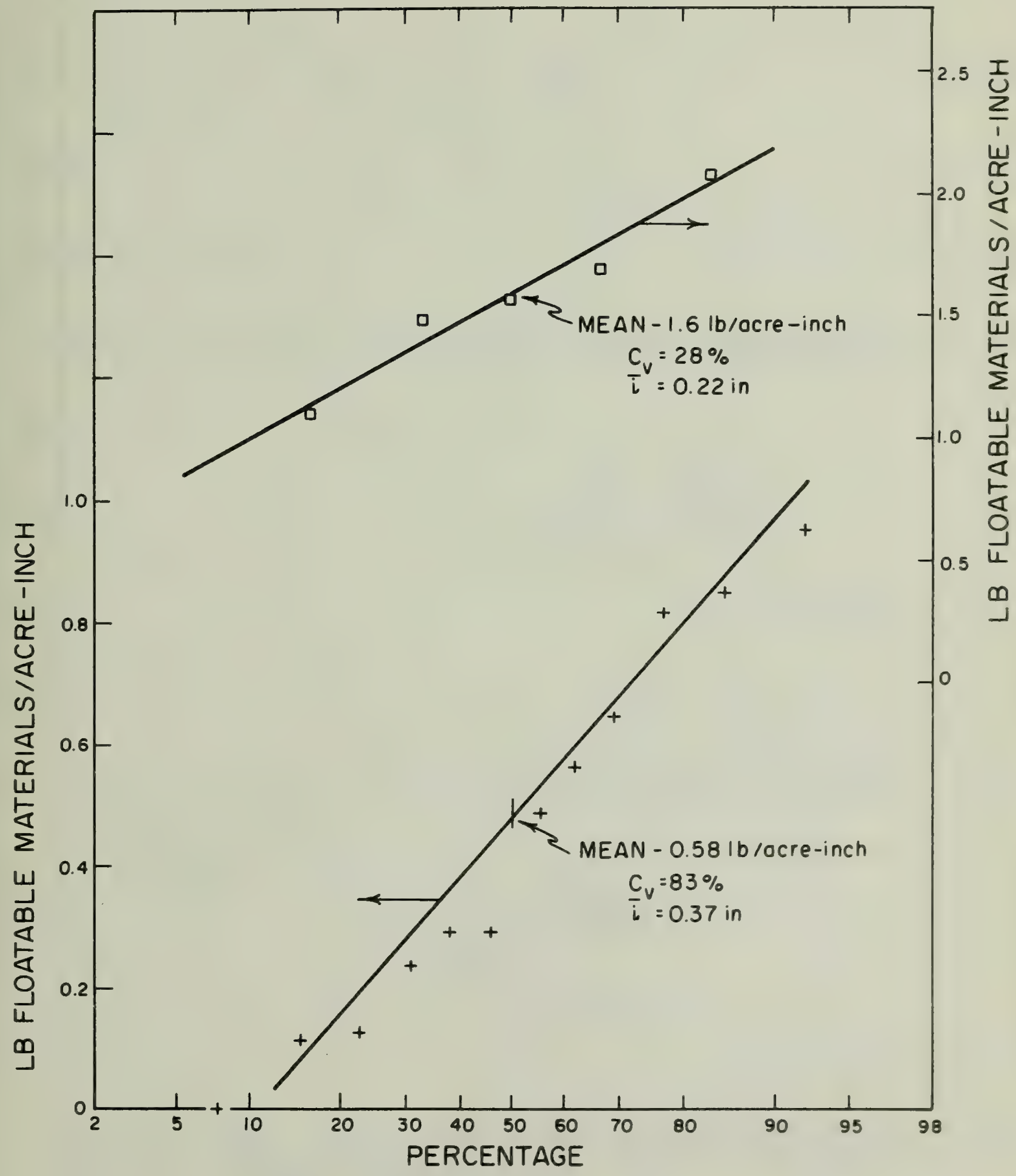
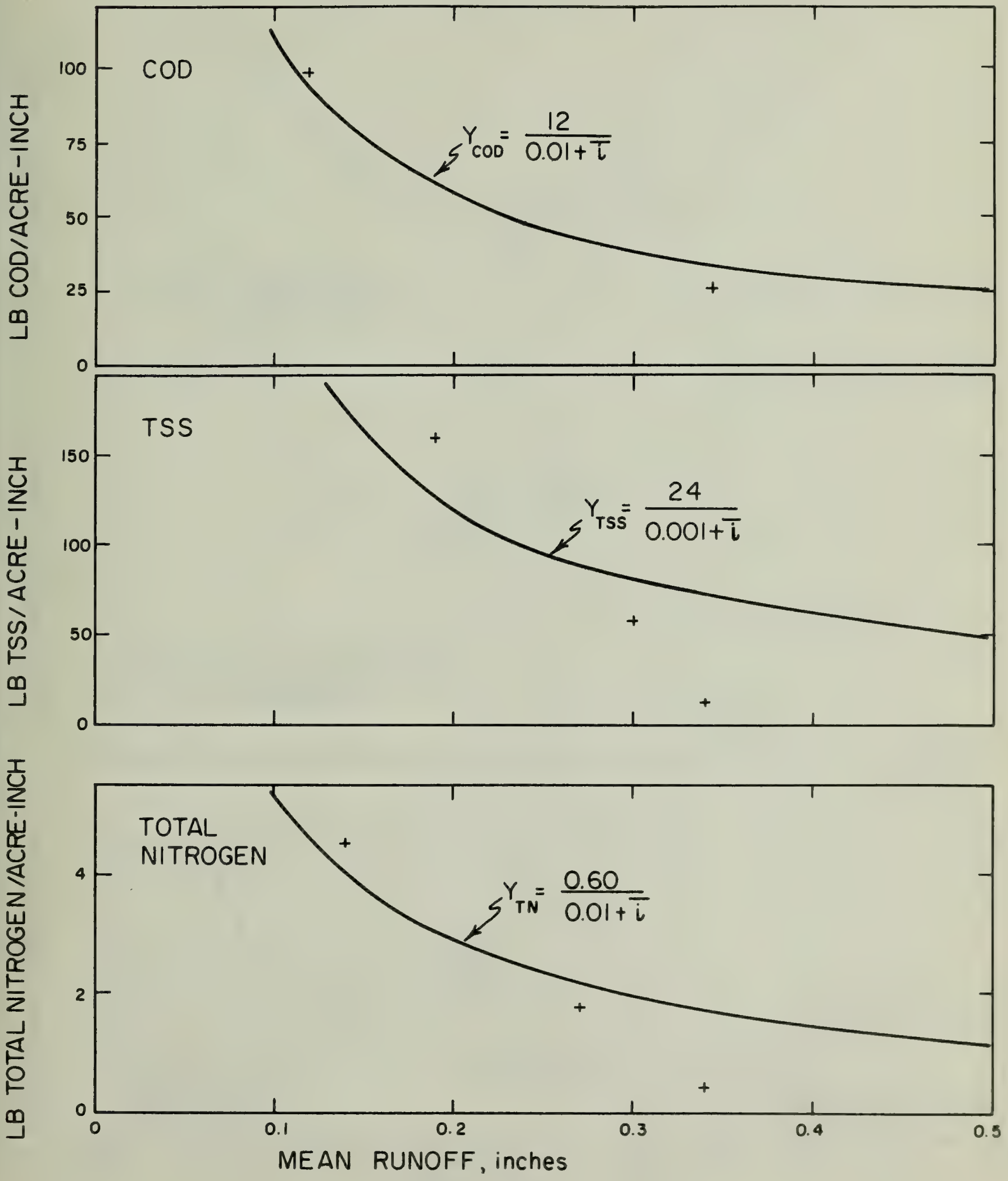
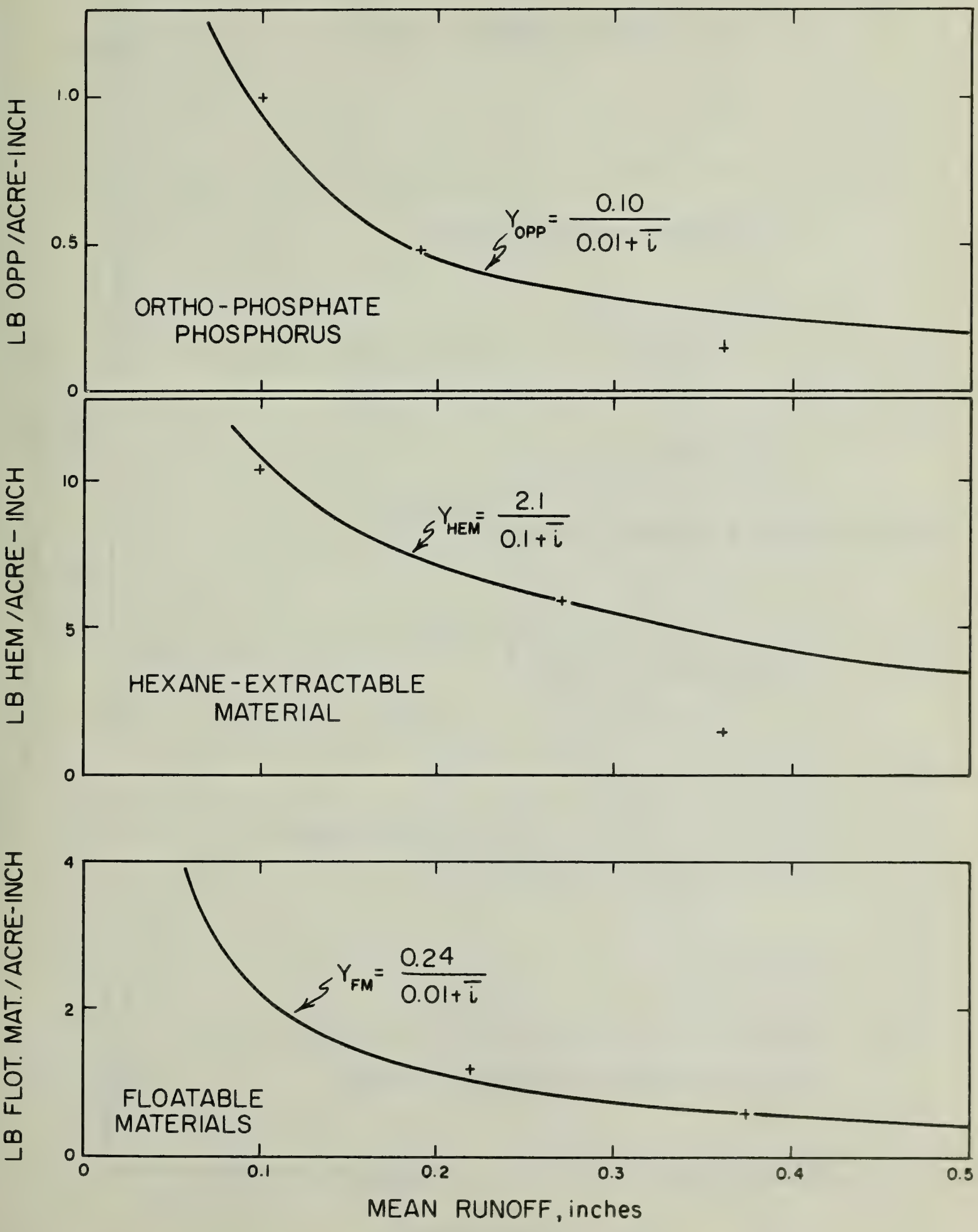


FIGURE V-27

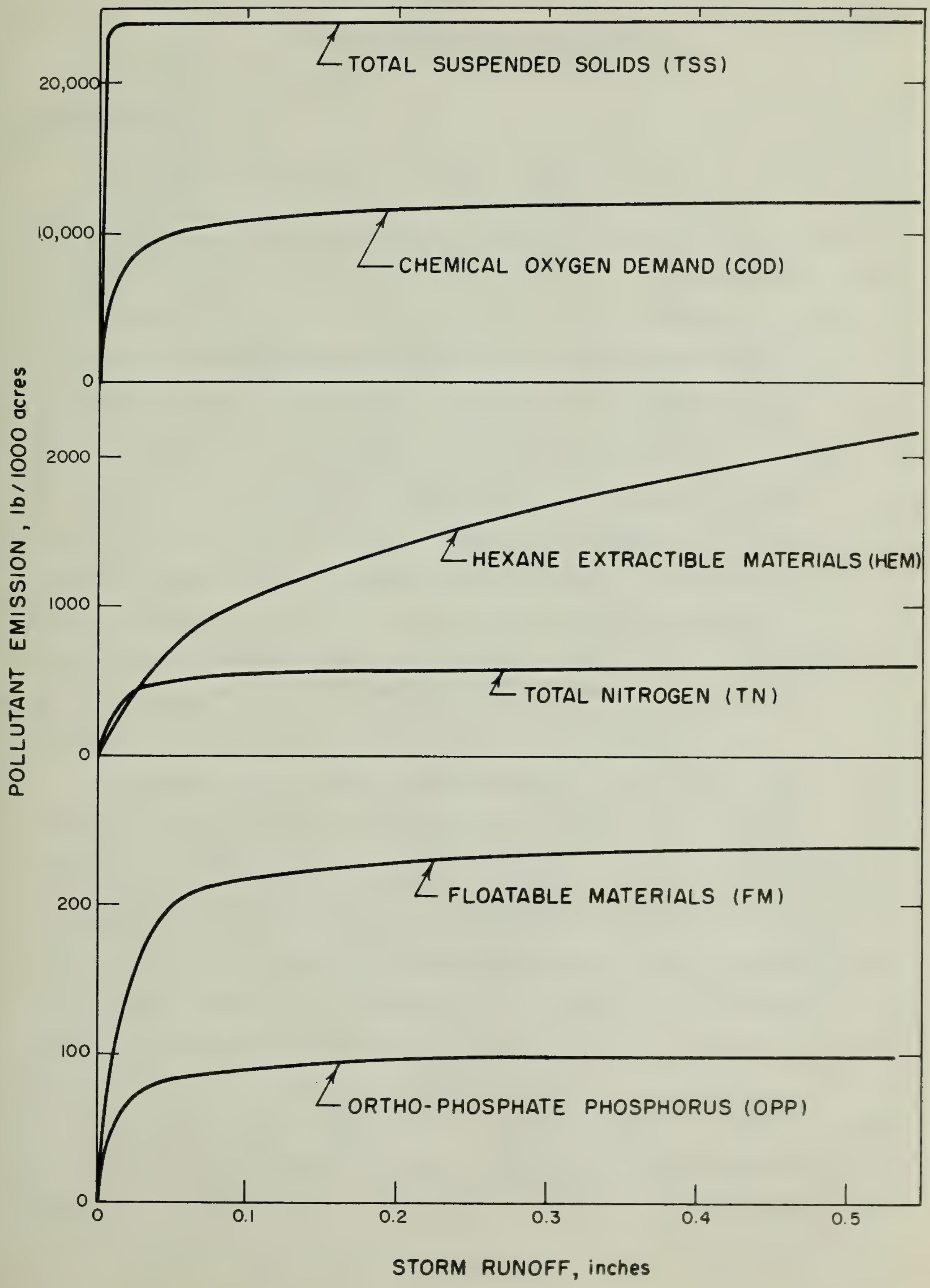
VARIATION OF MEAN MASS EMISSION COEFFICIENT (LB/ACRE-INCH)
WITH MEAN RUNOFF IN DATA DISTRIBUTION
COD-TSS-TOTAL NITROGEN



VARIATION OF MEAN MASS EMISSION COEFFICIENT (LB/ACRE-INCH) WITH MEAN RUNOFF IN DATA DISTRIBUTION ORTHO-PHOSPHATE PHOSPHORUS-HEM-FLOATABLES



PREDICTED STORM RUNOFF POLLUTANT EMISSIONS PER 1000 ACRE AREA, CITY AND COUNTY OF SAN FRANCISCO



CHAPTER VI

BAKER STREET RECEIVING WATERS

INTRODUCTION

The receiving waters of the Baker Street Outfall are immediately upstream of the Golden Gate Straits, and water movements and quality in the former area are closely associated with tidal action and advective outflow through the Golden Gate (Figure VI-1). The narrow entranceway to the Bay provides a confining function to the movement of waters in and out of the Bay and oceanic tidal influences are greatest in and just upstream from the Straits. The area immediately upstream from the Golden Gate can be visualized in the classical "low-end-of-the-river" context in that all discharges to the San Francisco Bay are upstream to this area. The environment of the Straits is essentially marine during the flood tide conditions due to the inland movement of oceanic waters, and is a combination of fresh water, salt water, and wastewater during ebb tide conditions. It is this situation which increases the complexity of assessing the impact of the discharges on the characteristics of the receiving environment immediately upstream of the Golden Gate and in the area of concern to this study (Figure VI-2).

The need exists in the pre-evaluation study for developing reference information on the hydrodynamic and water quality aspects of the Study Area. Definition of the hydrodynamics requires a documentation of both the circulation patterns in the general confines of the San Francisco Bay as well as past the Baker Street Outfall, and the distribution of discharges from the Baker Street Outfall into the receiving waters. Definition of water quality requires a consideration of esthetic, health, and ecological factors on both a temporal and spatial basis.

To satisfy these needs within the constraints of the pre-evaluation study, the program described in Appendix A was conducted, and the results therefrom are presented and evaluated in this chapter.

HYDRODYNAMICS OF SAN FRANCISCO BAY

General Systems

San Francisco Bay resembles in many ways a landlocked sea more than a Bay (Figure VI-1). Its 340 square miles of surface water is connected with the Pacific Ocean only via the Golden Gate Straits which are less than one mile wide. Together with varying hydrologic and hydraulic features, the shoreline and bottom configuration contribute to the formation of complex water circulation patterns.

The tides of the San Francisco Bay reflect the tidal characteristics of the North American Pacific Shelf. Generally, the cycle is that of a double tide: a long flood and a long ebb followed by a short flood and a short ebb. The total double sequence takes place in about 24.75 hours. The tidal cycle can be described in terms of tidal currents stage and tidal height. The four tidal current stages are:

(1) Low slack: occurring between the second and third hour after maximum ebb current.

(2) Flood: occurring between the second and third hours before maximum flood current.

(3) High slack: occurring between the maximum flood current and the second hour after maximum flood current.

(4) Ebb: occurring between the third hour after maximum flood current and the first hour after maximum ebb current.

The tidal heights are: mean high high water (MHHW), mean low low water (MLLW), mean high water (MHW), and mean low water (MLW), occurring at the completion of the long flood, long ebb, short flood, and short ebb tidal current stages, respectively. The volume of the tidal prism at the Golden Gate Bridge between MHW and MLW at the point is 1.25 million acre-feet (Reference VI-1).

Vertical water movements of five to seven feet occur over the tidal cycle at the Golden Gate. While tides are manifest throughout the Bay, they decrease in amplitude with increasing distance from the straits. Tidal energy resulting from the easterly or westerly flow of water

through the Golden Gate contributes significantly to current patterns in regions immediately adjacent to the straits. This energy is dissipated as the tidal sweep enters the wider and shallower sectors of the Bay system. Consequently, local topography, bottom contour, and pertinent fresh water sources play an important part in determining water movements throughout the Bay.

Water currents in the receiving environment of the Baker Street outfall are related to both the influence of the tidal cycle and to local topography. The information used to document these relationships in the Study Area was obtained from various publications (References VI-2 and VI-3) and by observations with the San Francisco Bay-Delta Model (United States Army Corps of Engineers). Initial discussion is directed to observations made using the Bay-Delta Model.

Observations from Bay-Delta Model on Baker Street Receiving Waters

The Bay-Delta Model was observed under an operating mode simulating tidal flow conditions in the Bay for the period of 28 to 29 March 1960. The combined outflow of the Sacramento-San Joaquin River system during this period was 28,000 cfs; this flow was simulated during model operation. Water movements in the sector of the model simulating the Baker Street receiving environment were traced from observations of floating and submerged markers. Eddy behavior was diagrammed from floating marker migrations, and from visual observations of the water movements in the model. To assist in determination of specific surface patterns, floating markers were released to the model system from points at scale distances of: nearshore (less than 50 ft); 300 to 500 ft; 1,000 feet; and 1,500 feet from the mouth of the existing (March 1970) Baker Street outfall.

During flood tide the general flow of ocean water past the Study Area was observed to extend past the Embarcadero and toward the South Bay. At the higher flood stage, incoming surface water was observed to be capable of transporting markers past Hunter's Point; while at the lower flood stage markers were transported into the China Basin region just south of the San Francisco end of the Bay Bridge. As the tide

shifted, the markers were transported past the Baker Street region, and into the region of Fort Point.

From the existing information and the visual observations, a description of the eddy patterns in the area immediately to the west of the Baker Street outfall can be hypothesized. The model sequence was started at a scale time of 2400 hours with full ebb tide and ended at 2230 hours with the start of another full ebb tide. The current patterns developed with the model are illustrated sequentially in Diagrams 1 to 16 of Figure VI-3, and are described as follows:

Immediately after a tidal reversal, and start of full ebb, all water flowed past the Study Area in the same direction and with no eddy patterns evident (Diagram 1). As the outflow increased, a small eddy 100 to 200 scale-feet in diameter began to form close to the beach ((Diagram 2). As the ebb tide slackened, the counter-clockwise eddy increased in size (Diagram 3) and reached a maximum size just prior to the start of the flood tide (Diagram 4). The incoming water was observed to destroy the ebb eddy, after which waters began to move to the east in from the Baker Street outfall area; no eddy patterns were observed during the time period (Diagram 5). As the flood tide lessened an eddy began to form about 800 feet to the west of Baker Street and moved in a clockwise direction (Diagram 6). As tidal flow continued to slacken, this eddy increased in speed and lengthened to form an elliptical gyre extending along the entire front of the beach (Diagram 7). As the ebb tide began (Diagram 8), the eddy became more circular and moved offshore (Diagram 9). Gradually the eddy was dissipated by the ebb tide and the flow pattern was restored to that of full ebb (Diagram 10). The second stage of the tidal cycle was observed to be similar in effect to that of the first stage and water current therefrom are described in Diagrams 11 through 16.

A second series of drift marker observations were made utilizing the Bay-Delta Model and the release of markers at various distances from the Baker Street outfall location. The nearshore relases are described as follows:

About ten markers were released at flood and ebb tide at a scale distance less than 50 feet from the Baker Street outfall. During simulated ebb tide, the movements of the released markers indicated that a counter-clockwise eddy was formed immediately off the beach to the west of the outfall. Eventually, some of the surface water moved westward along the beach of Crissy Air Field and then entered another counter-clockwise eddy established along the entire beach. One-half of the released floating markers ended up on Outer Marina Beach (Figure VI-4). The remaining markers were beached in the area of Crissy Air Field. After numerous tidal cycles, some markers had moved out the Golden Gate into the ocean.

During simulated flood tide, the movement of the markers indicated that the surface waters form an eddy moving in a clockwise direction. The markers were eventually either deposited on the Baker Street beach or transported eastward towards the Embarcadero. Marker movement indicated that some surface water flowed into the St. Francis Yacht Harbor. Most markers were deposited among Embarcadero piers in the model, and some markers travelled as far east as the western end of the Bay Bridge (Figure VI-4).

In summary, the marker movements indicated that water movements were rather sluggish along the Crissy Air Field Embarcadero shoreline. Most of the markers released in nearshore zone (less than 50 feet to shore) appeared to shift back and forth between the Crissy Air Field and the Embarcadero. Numerous tidal shifts were required before a substantial number of markers moved out the Golden Gate or into the South Bay. Consequently, water exchange was poor.

The same type of experiment described above was repeated except that the markers were released at scale distances of 200 to 500 feet from the Baker Street outfall. The results of these releases are described as follows:

Most of the markers travelled westward and were circulated in the Crissy Air Field and Baker Street eddies, or else were moved out the Golden Gate and circulated in the Baker's Beach eddy just west of Fort Point (Figure VI-5). Markers released on flood tide either entered

the Baker Street eddy or moved to waters in front of the Embarcadero, usually clear of the piers. Some markers travelled as far east as China Basin (Figure VI-5). Markers in the surface water eddying off Baker's Beach were transported ultimately past the Study Area and eastward along the Embarcadero.

As noted previously with the nearshore releases, several tidal changes were required to free a substantial amount of surface material from the back-and-forth movement. Mixing with adjacent waters appeared to take a considerable number of tidal cycles.

The dispersion of markers released at a scale distance of 1,000 feet from the Baker Street outfall is described below:

Markers released at ebb tide moved freely past the eddies at Outer Marina Beach and Crissy Air Field Beach and were transported around the Fort Point area. Except for some markers entering a large counter-clockwise eddy off Baker's Beach (scale diameter of one mile or so), the rest were transported to the ocean (Figure VI-6). Markers released on flood tide moved several hundred feet off the Embarcadero into China Basin and as far as Hunter's Point (Figure VI-6). Data from the Reference VI-3 for Station 36 (near the Baker Street outfall) from 1951 to 1954 indicated that water movement at this distance from shore is predominantly shoreward; this was confirmed by model observations. In summary, markers released at a scale distance of 1,000 feet offshore were generally transported out of the Golden Gate. Those released during flood were transported as far as Hunter's Point, but were generally transported out the Golden Gate with the next ebb. On the basis of the distribution of the surface markers, it appears that water exchange at a scale distance of 1,000 feet offshore was superior to that observed for release sites closer to the shoreline.

The final set of releases were conducted at a distance of 1,500 feet from the Baker Street outfall:

The markers released at ebb tide moved clear of the eddies to the west; however, some markers entered the Baker's Beach eddy beyond the Golden Gate. The remainder headed out to sea (Figure VI-7).

Marker releases during flood tide moved rapidly at a scale distance and southerly about 1,000 feet offshore from the Embarcadero to beyond Hunter's Point into South San Francisco Bay. After several tidal sequences, a few of the markers were found in the sector of the model simulating the Embarcadero piers. Possibly these markers entered a longshore current system in the model and were returned to the area of Embarcadero piers (Figure VI-7).

In summary, the effect of flood and ebb tides on the movement of markers released at a distance of 1,500 feet offshore was found to be essentially equal. Markers transported on the incoming tide were moved sufficiently far into the South Bay sector of the model that numerous tidal cycles would appear to be necessary to transport them permanently beyond the Golden Gate. For this reason the simulated water movement in the area at a distance of 1,000 ft offshore appeared more advantageous than those in the zone 1,500 ft offshore insofar as surface water dispersal and seaward transport are concerned.

One shortcoming of the previous experimental information is that the model dispersion-studies were conducted under windless conditions. Potential impact of winds on these dispersion patterns should be considered in prototype studies.

In the absence of oceanic current intrusion, the water movements on the Pacific Shelf of North America are greatly affected by prevailing winds. Most of the storms occurring in the San Francisco area come from either the northern or southern quadrants, and consequently, the wind direction is northerly or southerly. Under these conditions, sufficient fetch exists in certain regions to permit the formation of waves in excess of five feet in height (Reference VI-4).

Swells of oceanic origin enter the Golden Gate under certain conditions; however, they generally dissipate quickly and less than 10 percent exceed two feet at Alcatraz Island (Reference VI-5). These small swells from the west run parallel to Outer Marina Beach, and would be expected to decrease in energy content as they approach this area due to shoaling.

On the basis of available information, it would appear that wave action plays a relatively minor role in movement of water in the Study Area. The greatest consideration should be given to the effect of local currents and eddies in effecting transport and mixing of liquid wastes.

As a final comment to this section, some statements on the mechanisms of sand deposit at Outer Marina Beach can be made. The accumulation of sand at the Outer Marina Beach represents a continuing maintenance problem for the City of San Francisco. To counter this problem the City conducts bulldozing and sand removal operations several times a year in an attempt to prevent sand drom spilling over onto the nearby parking lot and into Yacht Club property.

Some understanding of the causes of this phenomenon can be gained from evaluation of the information on the water currents developed using the Bay-Delta Model. The following comments refer to the diagrams shown in Figure VI-3. As shown in Diagram 2, a small but increasingly rapid counter-clockwise eddy was observed which in prototype could remove sand from the center of the beach and deposit it at Location 1. As the eddy is enlarged (Diagram 3) the sand could be deposited at Location 2; however, the velocity of the eddy is decreasing at this time, in which case less sand would be transported to this area. The full flood tide (Diagram 5) would tend to deposit sand and other materials at Location 3. The deposition of sand at Location 4 (Diagram 6) would not be affected by the eddy to the west. By the time the clockwise eddy is large enough to extend easterly enough, it could be too weak to remove sand from Location 5 (Diagram 7). The ebb tide is not expected to be strong enough to remove sand from Locations 6 and 7 (Diagrams 8 and 9). Once again, after full ebb (Diagram 11) sand could be moved by the eddy from mid-beach and deposited at Location 8. As the eddy is moved offshore (Diagram 12) some sand could be removed from Location 9.

This sequence of events could explain how sand is accumulated in Outer marina Beach, but, as with the foregoing observations based on model operation, requires confirmation by study of the prototype directly.

WATER QUALITY CONSIDERATIONS

Introduction

The three field sampling efforts outlined in Appendix A emphasized water quality measurements in the receiving waters. Measurements were concentrated in the more dynamic sectors of water systems: that is to say, the liquid-air and liquid-sediment interfaces. Specifically, these sectors are the surface waters to a depth of three feet, the estuarine sediments, and the intertidal area of Outer Marina Beach. Selected physical, chemical, and biological considerations were made of the first two sectors, but only physical and chemical characterizations were made on the last sector.

As discussed in Appendix A, twelve receiving water stations and six intertidal beach stations were selected for sampling. The locations of these stations are shown in Figures VI-2 and A-3. Sampling at these stations was scheduled insofar as possible during high slack and flood tidal current stages to maximize the possibility of detecting the impact of discharges directly from the Baker Street outfall under tidal conditions found to minimize the impact of adjacent discharges easterly of this area on receiving water quality in the nearshore zone at the Baker Street outfall.

Surface Water

Turbidity

The optical properties of waters are important from an esthetic as well as an ecological viewpoint. Many of man's competitive and compatible uses of water are regulated, in part, by the optical properties of the water. Discolored and/or turbid water has no small impact upon the acceptability of water for drinking, bathing, swimming, boating, fishing, and industrial uses. From another viewpoint, the quantity and quality of light below the water surface influences directly, or indirectly, essentially every event occurring in waters whether they be lakes, ponds, streams, oceans, estuaries, or puddles. For example, solar radiation is the ultimate source of the heat content of water bodies. Temperature may be a rate limiting factor for all processes.

Underwater visibility is critical to many species of fauna for the successful capture of food items. Also, the extent of photosynthetic activity in water bodies is determined in large measure by the level of the photic depth. The ramifications of photosynthetic activity are evident at all levels of a living, aquatic ecosystem.

The three factors which reduce light passage are water (the medium), sestonic particles, and dissolved color. The combined total effect of variations in the expression of these three factors is additive; *viz.*, there is no interaction.

Water quality control practices are concerned with the regulation of suspended particles (detritus, plankton, and minerals) and of dissolved substances that impart a color to water. Manifestations of the former are treatment for solids removal at sewage treatment plants and at mining wastewater facilities. Recently, consideration is developing towards the control of injection of nutrient-laden waste flows to prevent planktonic "blooms" which reduce light passage through water. Manifestations of the latter are treatment for the removal of colored substances from many industrial wastewaters (*i.e.*, pulp and paper industries, petroleum industries). Interfering with the success of these practices are the natural contributions of suspended particles (silt) and dissolved, colored substances (humic and phenolic compounds) from watersheds to receiving waters.

In the San Francisco Bay system the main turbidity problems are sestonic in origin. The principal components of the seston are probably silt and detritus materials. On occasion, planktonic blooms will serve to increase turbidity levels. A gross measure of these sestonic components is suspended solids. As shown in Figure VI-8, an inverse relationship exists in San Francisco Bay between secchi disc transparency and the suspended solids concentration. The plot is based on mean data presented in Reference VI-6 (Figures VI-6 to VI-9). Data presented in Reference VI-6 also indicate a general decrease in water clarity with distance up either arm of the estuary from the Golden Gate. There is evidence to conclude that the parameter of suspended solids concentration

is a foremost factor regulating turbidity in the San Francisco Bay system.

During the pre-evaluation surveys of 1969 and 1970, three sets of secchi disc readings were made in the receiving waters. Measurements varied from 2.5 to 3.0 feet during the first survey (February 1969), from 5.5 to 6.0 feet during the second survey (May 1969), and were 3.0 feet during the third survey (January 1970) (Table VI-1). When a comparison is made between the 1960-1964 seasonal variation of mean transparency (Figure VI-9) and the three sets of survey data (Figure VI-8) in the Study Area, it is evident that the waters were less turbid during the study period than in the total Bay system in 1960-1964.

Floatable Materials

The materials floating on water surfaces in the environment are important from an esthetic as well as ecological viewpoint. Many of the beneficial uses of water can be impaired by the types and amounts of floatable materials. Impairments range from unattractive accumulation of floatable materials in eddy areas or on beach sands to the navigational hazards resulting from the presence of larger floatables. The presence of films on the water surface can hinder the gaseous exchange processes across the water surface. Diffusion processes are a necessary component of the carbon dioxide and dissolved oxygen circulation patterns in waters.

The Bay-Delta Study (Reference VI-7) contains data on levels of particulate, floatable material occurring on local nearshore coastal waters. Surface water samples from the Pillar Point, Ano Nuevo, and Monterey Bay area of California were found to contain from 0.5 to 2.6 mg of particulate matter per square meter of surface water, the mean value being 1.5 mg/sq m. A mean floatables level of 0.13 mg/sq m was observed in a sampling program performed near the Los Angeles County Sanitation District's submarine outfall-diffuser system (Reference VI-7). Information reported in the Bay-Delta Study (Reference VI-7) indicated that this level (approximately 0.15 mg/sq m) appears to be a background level for many coastal waters in California.

TABLE VI-1

SECCHI DISC TRANSPARENCY

PHASE I RECEIVING WATER STUDY

Date	Station and Secchi Disc Transparency, ft											
	1	2	3	4	5	6	7	8	9	10	11	12
SURVEY 1												
24 Feb 1969	3.0	3.0	3.0	3.0	3.0	3.0	2.5	3.0	3.0	3.0	2.5	3.0
25 Feb 1969	2.5	2.5	2.5	3.0	2.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
SURVEY 2												
26 May 1969	*	6.0	*	5.0	*	5.0	5.0	*	5.0	5.0	5.0	5.5
27 May 1969	*	5.5	5.5	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
SURVEY 3												
9 Jan 1970	3.0	*	3.0	*	*	3.0	3.0	3.0	3.0	3.0	*	*

NOTE: * No measurement made.

The amounts of particulate floatables in the nearshore receiving waters of the Baker Street outfall varied from 0.24 to 39.18 mg/sq m as observed in the present study (Table VI-2). The survey representing the dry weather conditions was conducted in May 1969, and the mean for all traverses was 0.55 mg/sq m. The remaining two surveys were performed during wet weather conditions in February 1969 and January 1970. The mean value for the former, as well as the latter survey, was 10.5 mg/sq m. It is evident that during wet weather conditions, the floatables levels in the nearshore receiving waters are one to two orders of magnitude greater than observed during dry weather conditions.

The spatial differences in floatables levels in the Study Area were not observed to be as definite as the temporal differences in the data collected in the present study (Table VI-2). Floatables were collected along 3,000 foot traverses from Station 1 easterly to Station 7 and from Station 1 westerly to Station 2 (Figure VI-2). For the single dry weather survey (May 1969), the floatables levels along the west and the east traverses averaged 0.44 and 0.68 mg/sq m, respectively. For the two wet weather surveys (February 1969 and January 1970), these levels averaged 7.8 and 12.1 mg/sq m. Thus, the average surface density of particulate floatable materials was found to be 50 percent greater easterly of the Baker Street outfall (extended) than it was westerly of this reference line.

The concentration of hexane extractable material (HEM) in the particulate floatables also varied significantly from dry to wet weather. During wet weather conditions (Table VI-2), HEM, as percent of particulate floatables, averaged two percent. The HEM for dry weather conditions was less than 0.01 percent for most of the samples. Thus, the surface density of HEM was found to increase by three to four orders of magnitude during wet weather conditions relative to dry weather.

The composition of the floatables obtained in samples from the three surveys are reported in Tables VI-3, VI-4, and VI-5. Assorted portions of plants and animals dominated the mass of floatables collected during all three surveys.

TABLE VI-2

PARTICULATE FLOATABLES DATA FOR NEARSHORE WATERS

PHASE I RECEIVING WATER STUDY

Date	Weather	Traverse (station to station)	Area Sampled (sq m)	Time	Tidal Stage *	Particulate Floatables (mg/sq m)	HEM (%)
24 Feb 1969	Wet	7 to 1	1,710	1153-1225	L. Slack	16.45	
		2 to 1	430	1240-1250	L. Slack	4.61	
26 May 1969	Dry	1 to 2	715	1757-1807	Flood	0.24	0.57
		2 to 1	450	1650-1658	Flood	0.54	0.00
		2 to 1	572	1818-1826	Flood	0.60	0.00
		1 to 7	369	1715-1722	Flood	0.54	0.00
		7 to 1	858	1733-1745	Flood	0.83	0.00
9 Jan 1970	Wet	7 to 1	1,144	1020-1040	Flood	39.18	1.42
		1 to 7	857	1045-1100	Flood	1.00	2.72
		2 to 1	685	1103-1115	H. Slack	4.44	1.22
		1 to 7	572	1120-1130	H. Slack	1.37	3.98
		7 to 1	857	1138-1153	H. Slack	2.46	1.81
		1 to 2	572	1200-1210	H. Slack	14.44	1.97

* Date:

24 Feb		26 May		9 Jan	
Time	Ht.	Time	Ht.	Time	Ht.
0448	5.1	0124	1.7	0124	5.1
1230	0.6	0718	3.8	0554	2.8
1954	3.7	1254	1.1	1154	6.6
2324	3.2	1948	5.4	1900	-1.6

TABLE VI-3

COMPOSITION OF SAMPLES OF FLOATABLE MATERIALS
24 February 1969

Traverse & Time	Characteristics	TSS (mg)	Mass/Area (mg/sq m)
Sta 7 → Sta 1	Greasy particles, grey to white, < 1 mm to 7 mm diameter	2,305.0	1.35
1153 - 1225	Cellophane & polyethlene-like matter, sizes < 5 x 5 mm to 5 x 25 mm	30.0	0.00
	Natural material, including seed, leaf & grass particles, etc.	25,860.7	15.10
	Total in sample	28,193.2	16.45
Sta 2 → Sta 1	Greasy particles, grey to white, < 1 mm to 4 mm diameter	477.8	1.11
1240 - 1250	Cellophane & celluloid-like matter	10.4	0.02
	Natural material	1,497.9	3.48
	Total in sample	1,986.1	4.61

NOTE: Wet weather.

TABLE VI-4

COMPOSITION OF SAMPLES OF FLOATABLE MATERIALS
26 May 1969

Traverse & Time	Characteristics	Solids (g)	HEM (mg)
Sta 1 → Sta 2	Sewage origin	0.0183	
	Plastic	0.0004	
	Natural	0.1522	
	Total in sample	(.239 mg/m^2)	5.70
Sta 2 → Sta 1	Sewage origin	0.0019	
	Natural	0.0847	
	Miscellaneous	0.1587	
	Total in sample	(.544 mg/m^2)	0.01
Sta 2 → Sta 1	Sewage origin	0.0401	
	Natural	0.0083	
	Miscellaneous	0.2937	
	Total in sample	(.598 mg/m^2)	0.03
Sta 1 → Sta 7	Sewage origin	0.0006	
	Miscellaneous	0.0009	
	Natural	0.1966	
	Total in sample	(.537 mg/m^2)	0.01
Sta 7 → Sta 1	Sewage origin	0.0065	
	Miscellaneous	0.0122	
	Natural	0.6895	
	Total in sample	(.825 mg/m^2)	0.01

NOTE: Dry weather.

TABLE VI-5

COMPOSITION OF SAMPLES OF FLOATABLE MATERIALS
10 January 1970

Traverse & Time	Characteristics	HEM (mg/g)	Mass/Area (mg/sq m)
Sta 7 → Sta 1 10:20 - 10:40 Area: 1,144 sq m	Vegetable material: wood, sticks, leaves, seeds, charcoal, algae		34.8
	Animal material: feathers, insects		0.38
	Nonsewage, human origin: cork, wax, paper, plastic		2.48
	Sewage origin: grease particles		0.14
	Remaining particles		1.38
	Total	14.2	39.18
Sta 1 → Sta 2 10:45 - 11:00 Area: 857 sq m	Vegetable material: stems, bark, roots, algae		0.70
	Animal material: hair, feathers, insects		0.01
	Nonsewage, human origin: plastic, paint chips		0.01
	Sewage origin: grease particles		0.01
	Remaining particles		0.27
	Total	27.2	1.00
Sta 2 → Sta 1 11:03 - 11:15 Area: 685 sq m	Vegetable material: sticks, leaves		3.76
	Animal material: feathers, insects		0.06
	Nonsewage, human origin: plastic, paint chips		0.05
	Sewage origin: grease particles		Trace:<0.01
	Remaining particles		0.57
	Total	12.2	4.44
Sta 1 → Sta 7 11:20 - 11:30 Area: 572 sq m	Vegetable material: sticks		0.02
	Animal material: feathers, hair, insects, fish scales		0.01
	Nonsewage, human origin		0.03
	Sewage origin: grease particles		0.01
	Remaining particles		1.30
	Total	39.8	1.37

TABLE VI-5 (Cont'd)

COMPOSITION OF SAMPLES OF FLOATABLE MATERIALS
10 January 1970

Traverse & Time	Characteristics	HEM (mg/g)	Mass/Area (mg/sq m)
Sta 7 → Sta 1 11:38 - 11:53 Area: 857 sq m	Vegetable material: wood, sticks, leaves, charcoal		1.38
	Animal material: feathers, hair, insect remains		0.17
	Nonsewage, human origin: paper, plastic, paint chips		0.09
	Sewage origin: grease particles		0.01
	Remaining particles		0.81
	Total	18.1	2.46
Sta 1 → Sta 2 12:00 - 12:10 Area: 572 sq m	Vegetable material: sticks, leaves algae, seeds		9.08
	Animal material: feathers, hair, marine anthropods		0.12
	Nonsewage, human origin: paper, plastic, wax, paint chips		0.97
	Sewage origin: grease particles		0.07
	Remaining particles		4.20
	Total	19.7	14.44

NOTE: Wet weather.

In summary, the results of the surveys in the nearshore zones bordering the Baker Street discharge indicate that the concentrations of floatables and HEM are dependent on sampling location and on the presence or absence of wet weather conditions. Levels of floatables and HEM during wet weather are significantly higher than those documented for dry weather conditions. Most of the particulate floatables are segments of plants and animals, and only a small portion is of sewage origin.

Coliform MPN

An analysis of historical coliform MPN levels observed in the shoreline sampling program of the City of San Francisco is presented in Appendix A. The locations of the City sampling stations are shown in Figure VI-10; Station 25 is located at Outer Marina Beach adjacent to the Baker Street outfall. The results of the analysis indicated that:

(1) The mean coliform MPN level at Station 25 (for all tidal current stages) was 320/100 ml during dry weather conditions, and 1,960/100 ml on rainy days (where a rainy day was defined as the day of, or following, a rainfall greater than 0.02 inches).

(2) The mean coliform MPN levels on rainy days at Station 25 were found to be three times greater at ebb and low slack tidal current stages than at flood and high slack stages.

(3) Coliform MPN levels decreased from mean wet to mean dry weather levels within five dry-weather days after a rainy day had occurred.

The total and fecal coliform data obtained at the 12 receiving water stations (Figure VI-2) during wet and dry weather periods in the present study are reported in Table VI-6. The lowest coliform levels prevailed in the receiving waters during the dry weather period (May 1969). Total coliform MPN levels varied from <2 to 2,400/100 ml and the median for all data was 140/100 ml. Fecal coliform values varied from 2 to 930 MPN/100 ml; the median for all data was 35 MPN/100 ml.

TABLE VI-6

COLIFORM CONCENTRATIONS
RECEIVING WATERS AT OUTER MARINA BEACH

Survey	Station and Coliform MPN/100 ml											
	1	2	3	4	5	6	7	8	9	10	11	12
24 Feb 1969												
Total	2,300	2,300	1,500	2,300	360	360	<36	910	360	360	910	910
Fecal	910	360	<36	2,300	360	<36	<36	360	360	<36	<36	360
25 Feb 1969												
Total	930	230	930	<30	430	2,400	930	30	2,400	2,400	150	200
Fecal	430	230	930	<30	430	2,400	930	30	930	2,400	150	200
26 May 1969												
Total	23	43	93	<2	<2	43	23	93	43	93	93	43
Fecal	23	9.1	23	<2	<2	9.1	9.1	93	23	23	93	9.1
27 May 1969												
Total	1,500	430	430	430	2,400	430	230	2,400	2,400	1,500	430	430
Fecal	430	230	91	73	730	230	91	930	43	750	39	43
9 January 1970												
Total	46,000	1,500	<300	910	9,300	4,300	910	110,000	110,000	360	24,000	360
Fecal	240	< 300	<300	360	1,500	1,500	910	110,000	910	360	360	<300

Station location: See Figure VI-2.

The median total coliform MPN level observed in the receiving water (140/100 ml) was over 50 percent less than the mean dry weather coliform MPN level of 230/100 ml observed at Outer Marina Beach (Station 25) between mid-1966 and December 1968.

The median coliform MPN level for all data obtained during the two wet weather surveys (February 1969 and January 1970) was approximately 10^3/100 ml. The median fecal coliform levels for all data for the two wet weather surveys was 450/100 ml. Thus, the median total coliform MPN observed under wet weather conditions in the receiving water (1,000/100 ml) was about 50 percent less than the mean wet weather coliform MPN level of 1,920/100 ml observed at Outer Marina Beach between mid-1966 and December 1968.

It is apparent from these observations that the coliform levels were approximately seven times greater during wet weather conditions than they were during the dry weather conditions. The fecal forms constitute a higher percentage (approximately 50 percent) of the total during wet weather than during dry weather (approximately 25 percent). A general relationship was observed between median coliform MPN levels observed in the receiving waters and median levels observed at the shoreline station at Outer Marina Beach, in which receiving water levels were 50 percent, or less, of the levels observed at the shoreline for both dry and wet weather conditions.

Additional spatial trends can be observed from the data in Table VI-6. Total coliform levels did not exceed 1,000 MPN/100 ml at the reference station (Station 12, Figure VI-2) during the 1969 to 1970 surveys. In the immediate area of the Baker Street discharge, except for Station 7 (3,000 feet to the east), levels exceeding 1,000 MPN/100 ml were observed at each station at least once during the three survey periods. A definite association between coliform counts and tidal stages and/or distance from Baker Street outfall was not evident.

Other Water Quality Measurements

Measurements of water temperature, chlorosity, and microplankton were also made during the pre-evaluation survey at the receiving water

stations (Figure VI-2). The measurements of water temperature and chlorosity are listed in Table VI-7. The results of the single microplankton analysis are listed in Table VI-8.

The minimum mean annual temperature at the Golden Gate is near 13°C (Reference VI-6). Water temperatures during the study periods averaged 11°C during the wet weather sampling period and 16°C during the dry weather survey (May 1969).

The chlorosity values for the January 1970 survey (Table VI-7) were near the normal level reported for this area (15 to 20 g/l; Reference VI-6). The chlorosity data for the February 1969 survey (Table VI-7) were rejected due to an early problem with the analytical technique.

The concentration of microplanktonic organisms varied from 64,000 to 92,000 organisms per liter of water sample (Table VI-8). These values are somewhat lower than would be anticipated on the basis of information presented in Reference VI-6. These data will be subjected to complete evaluation when the results of the post-evaluation study are available.

Benthos

Measurements of sediment composition, HEM, total nitrogen, total sulfide, and biota were conducted at Stations 1, 2, 4, 5, and 12 (Figure VI-2). The sediment samples consisted primarily of sand, with nine of the 10 samples containing at least 70 percent sand on a weight basis (Table VI-9 and Figure VI-11). These data are comparable with sediment composition data developed at Station 12 in the University of California Study (1960-1964, Reference VI-6).

The concentrations of HEM in sediment samples from Stations 1, 2, 4, 5, and 12 varied from 55 to 379 mg/kg of sediment (Table V-9). The February 1969 data suggest a difference in sediment HEM levels between the reference station (Station 12, Figure VI-2) and the remaining stations; however, the January 1970 data did not support this finding. The average HEM for sediments based on all data obtained in the two surveys was 212 mg/kg, a level which is nearly 50 percent less than the average level reported for the Central Bay area for the

TABLE VI-7

WATER TEMPERATURE AND CHLOROSITY

PHASE I RECEIVING WATER STUDY

Measurement	Date	Station											
		1	2	3	4	5	6	7	8	9	10	11	12
Temperature (^oC)	24 Feb 1969	10.5	10.0	10.0	10.5	10.5	10.0	9.5	10.0	10.0	10.0	10.0	10.0
	25 Feb 1969	10	10	10	10	10	10	10	10	10	10	10	10
	26 May 1969	16.5	16.3	16.3	16.7	16.6	16.8	16.7	16.6	16.0	16.8	16.9	15.0
	27 May 1969	16.2	16.4	16.3	16.2	16.3	16.3	15.9	16.1	16.3	16.3	16.1	16.0
	9 Jan 1970	12	12	12	12	12	-	-	12	12	12	12	12
Chlorosity (mg/1)	25 Feb 1969	5130	5140	-	5240	-	-	-	-	-	-	-	4150
	9 Jan 1970	16732	16702	16732	16912	16792	16852	16482	16624	17002	17022	16992	16852

NOTES: Wet weather surveys: February 1969 and January 1970.

Dry weather surveys: May 1969.

TABLE VI-8

MICROPLANKTON CONCENTRATION, RECEIVING WATERS AT OUTER MARINA BEACH, 25 February 1969

Station	1	4	5	12
Time	1324	1252	1355	1432
Total Concentration (10^3 org/l)	64.28	71.12	91.63	86.10
CHLOROPHYCOPHYTA				
Chlorophyta				
Ankistrodesmus sp.	2.0	1.7	1.7	2.3
Scenedesmus sp.	2.3	2.3	4.6	2.3
Unidentified	4.6	not counted	5.5	7.8
CHRYSOPHYCOPHYTA				
Centrales				
Chaetoceros sp.		0.58		
Coscinodiscus sp.	1.2	2.0	3.8	2.9
Leptocylindrus sp.	6.4	7.8	5.5	9.9
Melosira sp.	16.8	38	23.5	29
Rhizosolenia sp.	2.3	4.9	6.1	3.5
Skeletonema sp.	0.87		0.58	0.58
Thalassiosira sp.	10.2	3.5	7.5	6.7
Pennales				
Asterionella sp.			0.29	
Fragilaria sp.	0.87	1.2	0.29	3.2
Navicula sp.	4.3	4.4	7.5	7.5
Nitzschia sp.	2.6	1.7	1.2	3.2
Surirella sp.		0.29	0.87	0.58
Thalassiothrix sp.			1.2	
CILIATA				
Spirotricha				
Tintinnidae	0.87	0.87	1.2	0.58
Unidentified	0.58	0.29	2.0	0.58

TABLE VI-8 (Cont'd)

MICROPLANKTON CONCENTRATION, RECEIVING WATERS AT OUTER MARINA BEACH, 25 February 1969

Station	1	4	5	12
Time	1324	1252	1355	1432
Total Concentration (10^3 org/l)	64.28	71.12	91.63	86.10
PROTOZOA				
MASTIGOPHORA				
Dinoflagellata				
Gonyaulax sp.	5.8			
Euglenoidina				
Euglena sp.	2.3	1.3	16.8	4.9
Unidentified	0.29	0.29	1.5	.58

NOTE: Samples were lost for Station 2.

TABLE VI-9

BENTHOS DATA

PHASE I RECEIVING WATER STUDY

Date	Parameter	Station				
		1	2	4	5	12
24 Feb 1969	PSD*, wt %					
	Sand	93	82	54	86	93
	Clay	0	8	24	7	0
	Silt	7	10	22	7	7
	HEM, mg/kg	130	105	90	320	55
	Total Sulfide, mg/g	tr	.0087	.1470	.0296	tr
	Total Nitrogen, mg/g	0.12	0.18	0.72	0.21	0.10
9 Jan 1970	PSD*, wt %					
	Sand	90	83	80	78	70
	Clay	6	11	10	8	11
	Silt	4	6	10	14	19
	HEM, mg/kg	232	113	350	379	348
	Total Sulfide, mg/g	tr	.018	.160	.376	.194
	Total Nitrogen, mg/g	.072	.152	.600	.490	.428

* Particle Size Distribution

1960-1964 period (approximately 400 mg/kg; Reference VI-6).

The total sulfide values in the sediment samples from Stations 1, 2, 4, 5, and 12 varied from a trace to 0.376 mg/g of dry sediment (Table VI-9). These data support the concept advanced in the University of California Study (Reference VI-6) that the highest total sulfide contents in the San Francisco Bay were associated with the samples having the least concentration of sand.

The total nitrogen levels in the benthos sampling stations varied from 0.07 to 0.72 mg/g of dry sediment (Table VI-9). These levels are significantly less than the concentrations of 3 to 4 mg/g reported during the 1960-1964 period (Reference VI-6).

The taxonomic data on the biota of the sediments at the five locations are reported in Appendix I. In all surveys the fauna was found to be diverse in composition and dominated by annelid types.

Intertidal Zone

The locations of the six stations selected for littoral zone sampling are shown in Figure VI-2, and the characteristics of the sediments as observed in the present study are reported in Tables VI-9 and VI-10. During dry weather conditions (June 1969), the specific HEM content of beach materials varied from 8 to 32 mg/kg of sediment with a mean of 20 mg/kg (Table VI-9). Much higher HEM levels were observed during the two wet weather surveys; mean HEM levels of 95 to 62 mg/kg were observed during the April 1969 and January 1970 surveys, respectively. An explanation for this pattern is that there is a significant influx of HEM materials to the Bay system during wet weather conditions (as discussed previously in reference to floatable materials) which are available for deposition on littoral materials, particularly in areas such as Outer Marina Beach where sand is deposited continually.

A spatial trend in specific HEM content is also evident during the wet weather conditions. The HEM concentrations in the sediments at Stations 5 and 6 (over 1,000 ft westerly of the existing outfall alignment) were lower by a factor of at least two, relative to the levels observed at the stations nearer to the Baker Street outfall. The trend

TABLE VI-10

CONCENTRATIONS OF HEXANE EXTRACTABLE MATERIALS IN SEDIMENTS AT OUTER MARINA BEACH PHASE I BEACH INTERTIDAL ZONE STUDY

Characteristic	Station 1	2	3	4	5	6	Average
3 April 1969 (wet)							
HEM, mg/kg	2,093	91	158	108	58	71	97*
mg/sq m	23.02	1.00	1.74	1.19	0.64	0.78	
17 June 1969 (dry)							
HEM, mg/kg	23	32	12	8	38	11	21
mg/sq m	0.19	0.27	0.10	0.06	0.35	0.10	
9 January 1970 (wet)							
HEM, mg/kg	96	45	96	64	57	16	62
mg/sq m	0.80	0.37	0.80	0.53	0.47	0.13	

NOTE: * Data for Station 5 omitted from average.

of increasing HEM levels in the beach sediments as one progresses eastward parallels that observed in the receiving waters.

The particle-size distributions of the beach sediments at Stations 1 to 6 are reported in Table VI-11. The largest weight fractions of screened sediments consisted of sand particles in a size range passing an 0.295 mm screen mesh.

REFERENCE CHARACTER OF RECEIVING WATERS AND BEACH INTERTIDAL ZONE

The findings of this chapter provide considerable insight to the quality and hydrodynamic characteristics of receiving waters offshore from Outer Marina Beach, the impact of dry and wet weather on receiving water quality, and a correlation between receiving water and beach intertidal zone quality. Observations made with the Bay-Delta Model of the United States Army Corps of Engineers indicate that significantly different circulation patterns exist in waters more than 500 feet offshore than in the nearshore zone (where the present and new outfalls for the dissolved air flotation facility are and will be located). Beyond the 500-foot nearshore zone, there is a general easterly movement of Bay waters on flood tide and westerly movement on ebb tide. Within the nearshore zone, the above patterns also exist, but the westerly water movement breaks down during ebb slackening into a counterclockwise eddy and during flood slackening into a clockwise eddy. The effects of these eddies, the former of which appears to be the most significant, is to constrain the exchange of water in the nearshore zone with the main body of moving waters during much of the tidal cycle.

The Bay-Delta Model observations offer the implication, requiring further *in situ* investigation, that eddy formation and dissipation plays a significant role in delimiting the movement of Bay waters past the outfall dispersion zones. Eddy formation and dissipation are also believed to be the causative factors in the continuing deposition of sand on the central and eastern portions of Outer Marina Beach. Additionally, the current patterns during ebb tide transport waters from the southern estuary northerly and westerly into and past the receiving waters contiguous to Outer Marina Beach, transporting simultaneously

TABLE VI-11

SEDIMENT PARTICLE-SIZE DISTRIBUTION AT OUTER MARINA BEACH

PHASE I BEACH INTERTIDAL ZONE STUDY

Characteristic	Station					
	1	2	3	4	5	6
3 April 1969						
PSD*, wt %						
>1.168 mm	0.50	0.18	0.02	0.05	0.01	0.19
0.991	0.57	0.19	0.08	0.02	0.01	0.00
0.833	1.27	0.55	0.12	0.07	0.03	0.03
0.589	5.95	3.30	0.69	0.34	0.20	0.27
0.417	13.70	9.97	2.74	1.81	1.48	1.46
0.295	33.92	37.43	21.37	19.33	16.64	14.19
0.208	32.85	36.69	47.41	49.28	41.88	36.49
<0.208	11.24	11.70	27.57	29.10	39.75	47.41
17 June 1969						
PSD*, wt %						
>1.168 mm	0.05	0.00	0.03	0.40	0.45	1.53
0.991	0.06	0.01	0.04	0.47	0.27	0.85
0.833	0.24	0.06	0.09	0.92	0.61	1.41
0.589	2.79	0.30	0.93	4.26	2.56	5.11
0.417	9.36	1.29	4.53	7.59	5.37	6.91
0.295	31.80	15.98	22.48	23.33	14.48	15.72
0.208	35.54	46.14	40.42	35.22	33.93	28.18
<0.208	20.16	36.22	31.48	27.80	42.33	40.30
9 January 1970						
PSD,* wt %						
Sand	92	88	88	92	93	83
Silt	1	3	5	1	3	9
Clay	7	9	7	7	4	8

NOTE: * Particle size distributions based on dry sieving; sieve openings are in millimeters.

significant quantities of diluted treatment plant effluents and combined and storm sewage flows into this area during wet weather.

The floatable material and coliform MPN parameters manifested the most significant variations between dry and wet weather conditions of all the water quality parameters considered. The average floatable particulate concentration in wet weather was 10.5 mg/sq m, or over an order of magnitude greater than the average dry weather concentration of 0.55 mg/sq m. The average dry weather concentration in surface waters was 0.44 mg/sq m westerly of the existing outfall alignment and 0.68 mg/sq m easterly of the alignment. The wet weather levels were 7.8 mg/sq m in the westerly sector and 12.1 mg/sq m in the easterly sector, indicating that levels in waters easterly of the alignment are over 50 percent greater in all seasons than are waters in the westerly sector. It is noteworthy that there are no sanitary sewage discharges or combined sewer overflows westerly from the Baker Street outfall to Baker's Beach outside of the Golden Gate. The HEM fraction of the floatable particulate increased from 0.01 percent in dry weather to two percent in wet weather; because of the order of magnitude variation in floatable particulate levels between dry and wet weather, it is evident from the findings of this study that HEM levels varied by three to four orders of magnitude between dry and wet weather in the receiving waters of Outer Marina Beach. In spite of this significant increase, most ($\geq$98 percent) of the particulate floatables are of plant or animal rather than of sewage origin.

Median coliform MPN levels varied significantly between dry and wet weather both in the shoreline and offshore sampling stations. The median coliform MPN levels at Outer Marina Beach (Station No. 25) from mid-1966 to December 1968 were 320/100 ml in dry weather versus 1,960/100 ml on rainy days (>0.02 in. rainfall), or a factor of six difference between dry and wet weather median levels. The median coliform MPN levels in the receiving water grid sampled in this study (250 to 1,500 ft offshore) were 140/100 ml in dry weather and 1,000/100 ml in wet weather, *i.e.*, a difference of a factor of seven. Thus, a similar level of change in coliform MPN levels was observed at both the shoreline and offshore stations.

The tidal current stage was also found to be a significant variable affecting the wet weather coliform MPN level at the Outer Marina Beach shoreline Station No. 25. Median coliform MPN levels at flood and high slack stages during wet weather were approximately 1,200/100 ml, or one-third the median levels observed at this station for ebb and low slack stages. The distributions of coliform MPN levels between flood/high slack and ebb/low slack stages were found to be significantly different at a 68 percent confidence level, and are strong evidence of the impact of wet weather wastewater discharges easterly of receiving waters contiguous to Outer Marina Beach on the quality of these waters.

The beach intertidal studies indicate that a positive trend also exists in changes in HEM levels in the receiving waters and beach intertidal zone between dry and wet weather conditions. The mean specific HEM content of intertidal zone sands varied from 20 mg/kg in dry weather to 97 mg/kg during the April 1969 wet weather survey and 62 mg/kg in the January 1970 wet weather survey. These changes correlate positively with increases in HEM levels in receiving water floatable particulates of three to four orders of magnitude, and offer strong evidence of the interdependence of receiving water and beach intertidal zone quality in the Study Area.

CHAPTER VI - LIST OF REFERENCES

VI-1 *"A Comprehensive Study of San Francisco Bay, Volume IV"*, Physical and Hydrological Characteristics of San Francisco Bay, SERL Report 65-10, University of California (Berkeley), 1965.

VI-2 *"Report on the Treatment and Disposal of the Sewage of the City and County of San Francisco, California"*, Board of Consulting Engineers, May 1935.

VI-3 *"Special Tide and Current Survey, San Francisco Bay"*, United States Coast and Geodetic Survey, 1954.

VI-4 Johnson, J.W., *"Summary of Wave Data for San Francisco Bay and Vicinity"*, University of California:Department of Engineering, 1953.

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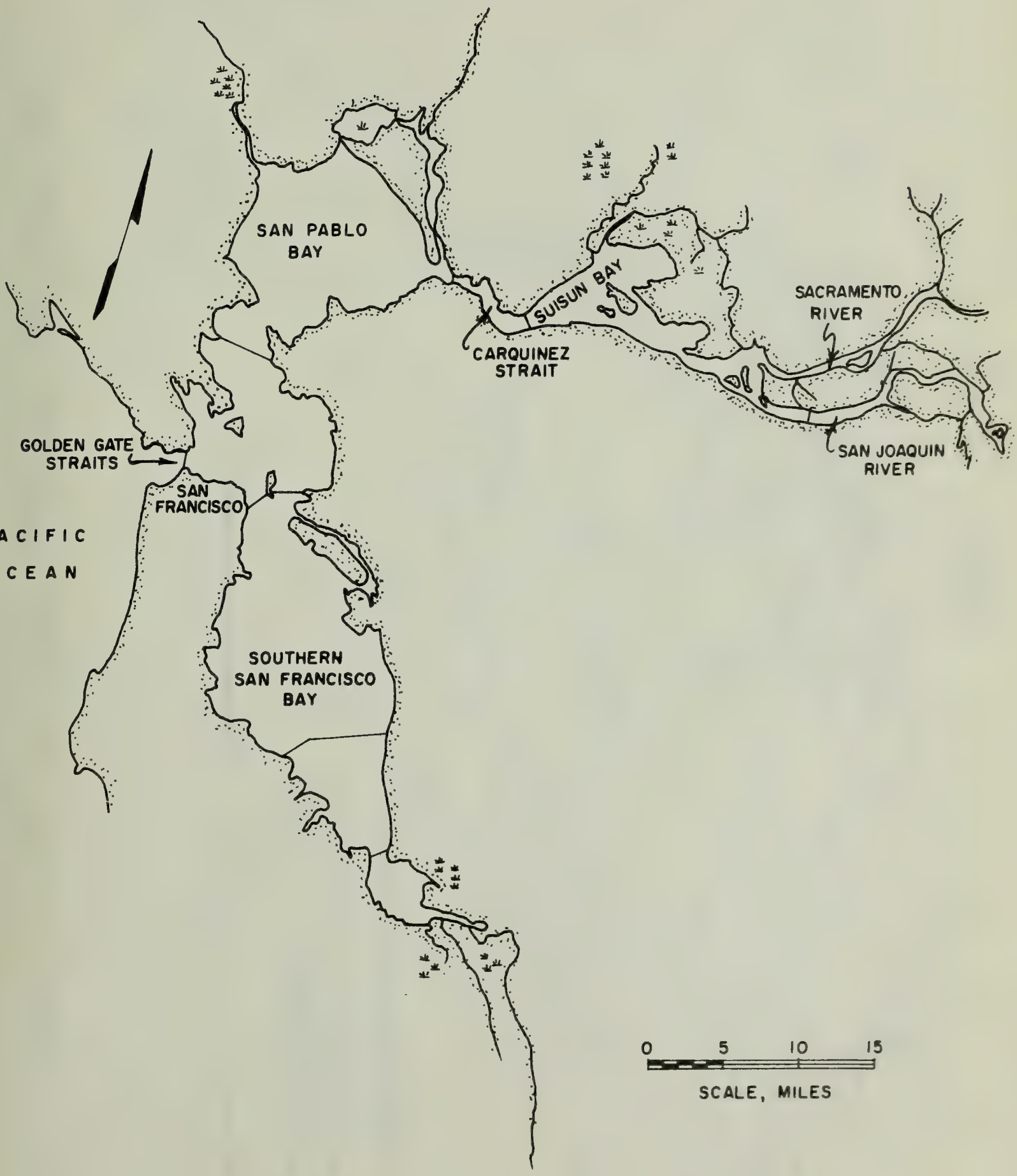
VI-6 *"A Comprehensive Study of San Francisco Bay, Volume V"*, Summary of Physical, Chemical, and Biological Water and Sediment Data. SERL Report No. 67-2, University of California (Berkeley) 1966.

VI-7 *"Task Report VII: Oceanographic Studies"*, San Francisco Bay-Delta Water Quality Control Program, 1968.

VI-8 *"Water Quality Criteria"*, Publication No. 3-A. State Water Quality Control Board State of California, 1963.

SAN FRANCISCO BAY AREA



SOURCE:
FINAL REPORT, A COMPREHENSIVE
STUDY OF SAN FRANCISCO BAY
VOLUME IV JUNE 1966
(REFERENCE VI-1)

FIGURE VI-2

RECEIVING WATER AND BEACH INTERTIDAL ZONE STUDY AREA

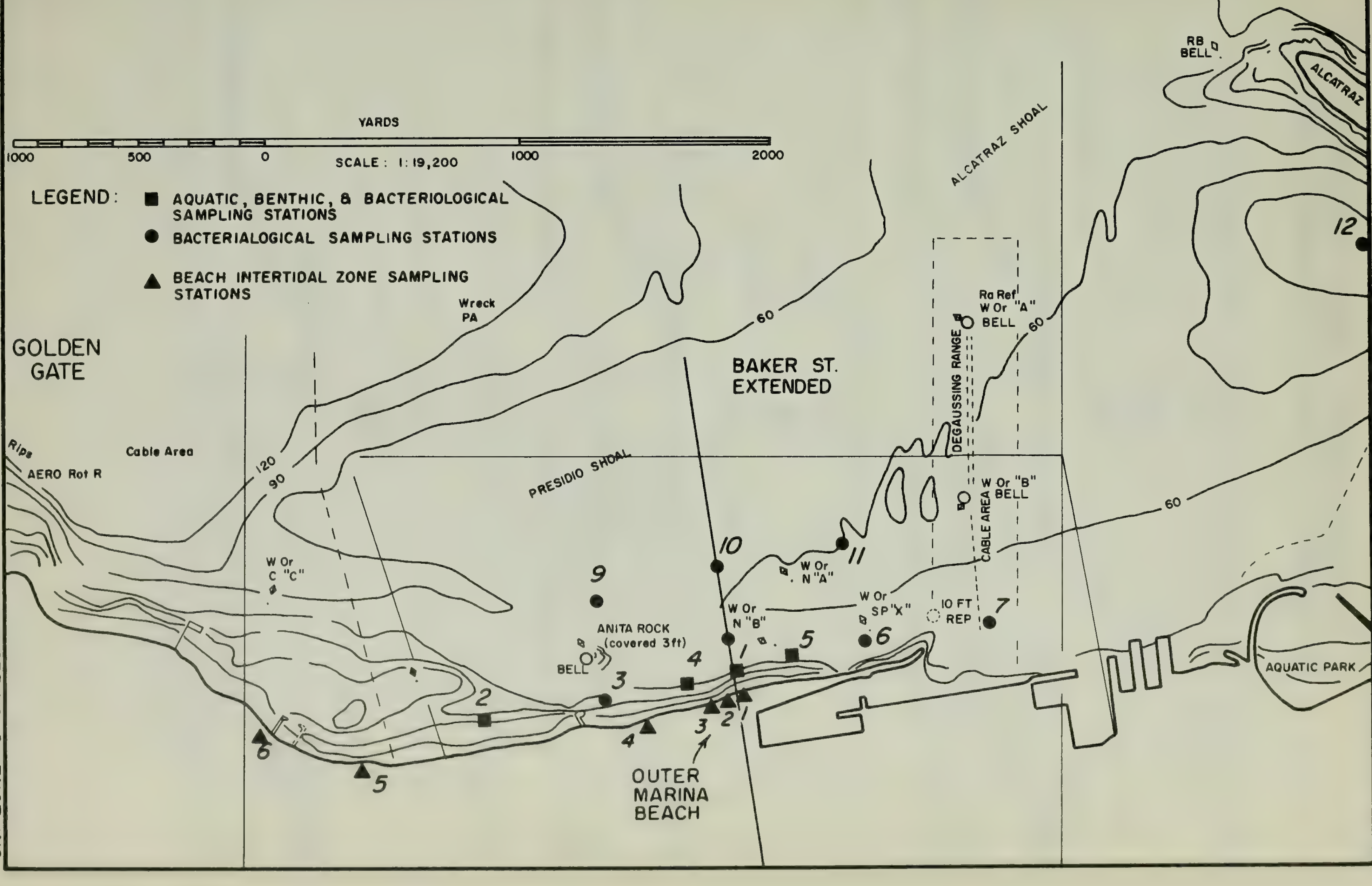


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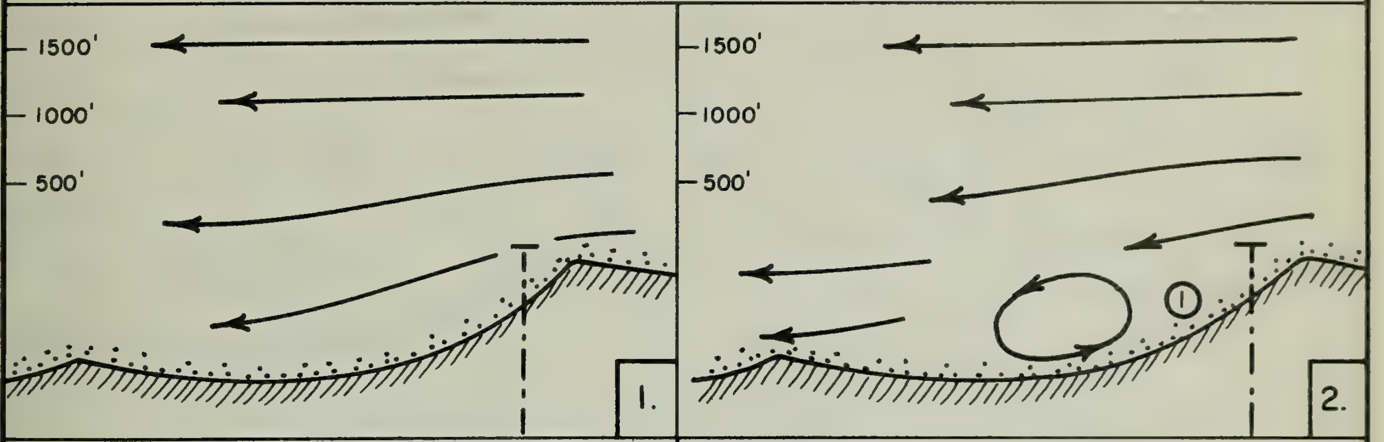
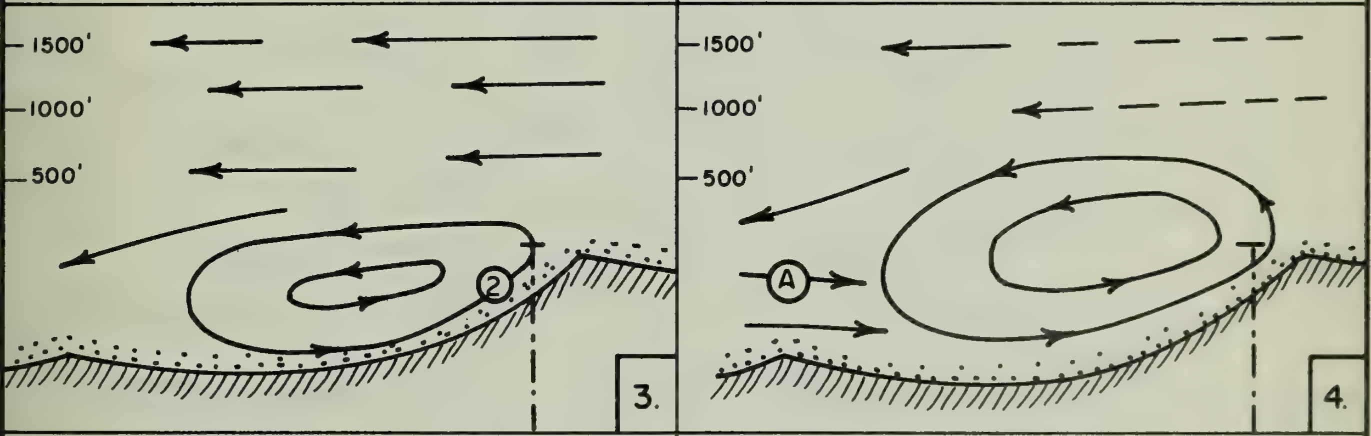
FIGURE VI-3

BAY-DELTA MODEL OBSERVATIONS OF TIDAL DYNAMICS IN PHASE I STUDY AREA



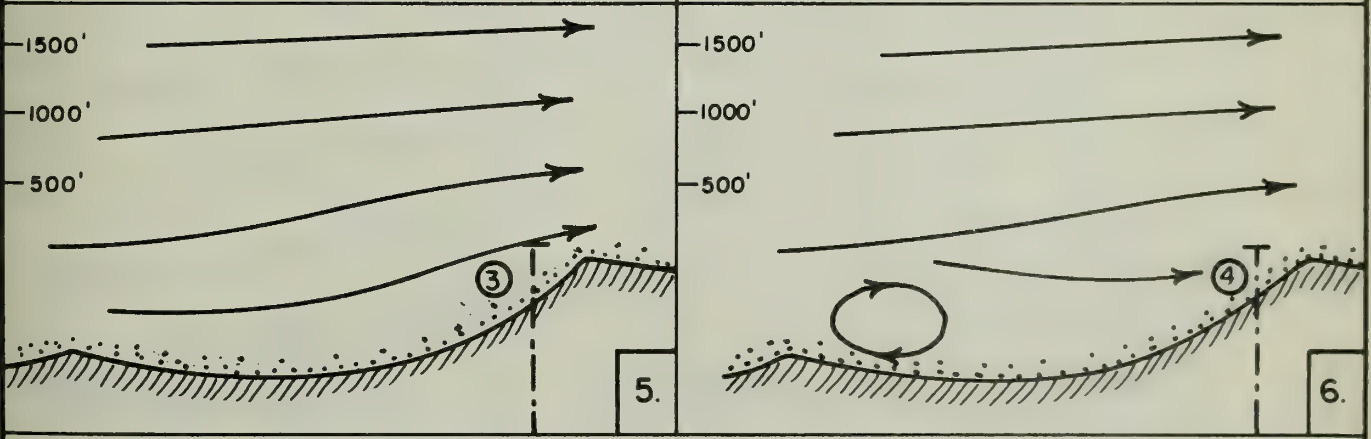
0000 FULL EBB NO. I

0100 EBB SLACKENING



0200 CONTINUED SLACKENING

0430 FLOOD BEGINS AT A



0530 FULL FLOOD NO. I

0630 FLOOD SLACKENING

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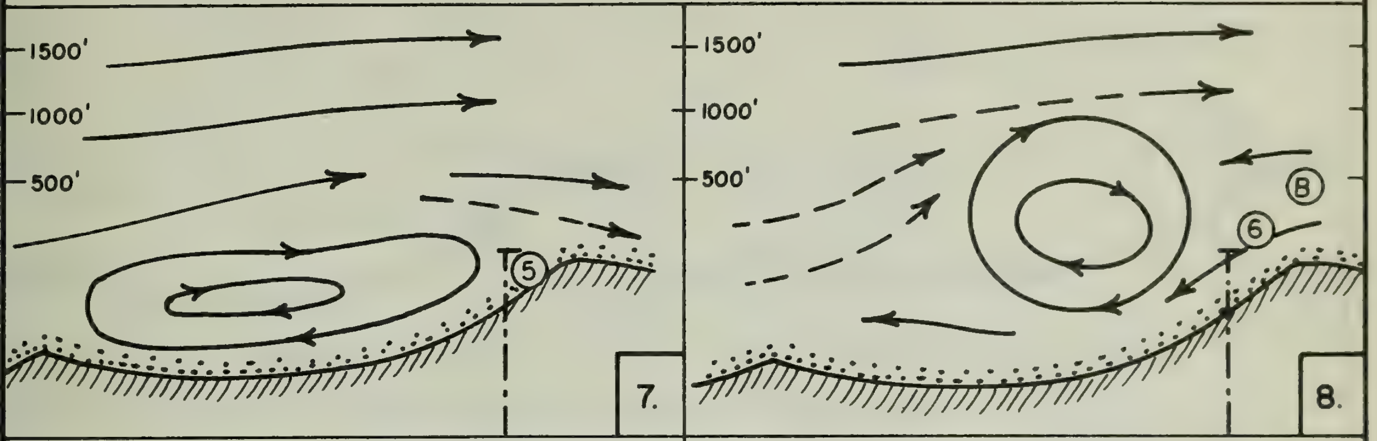
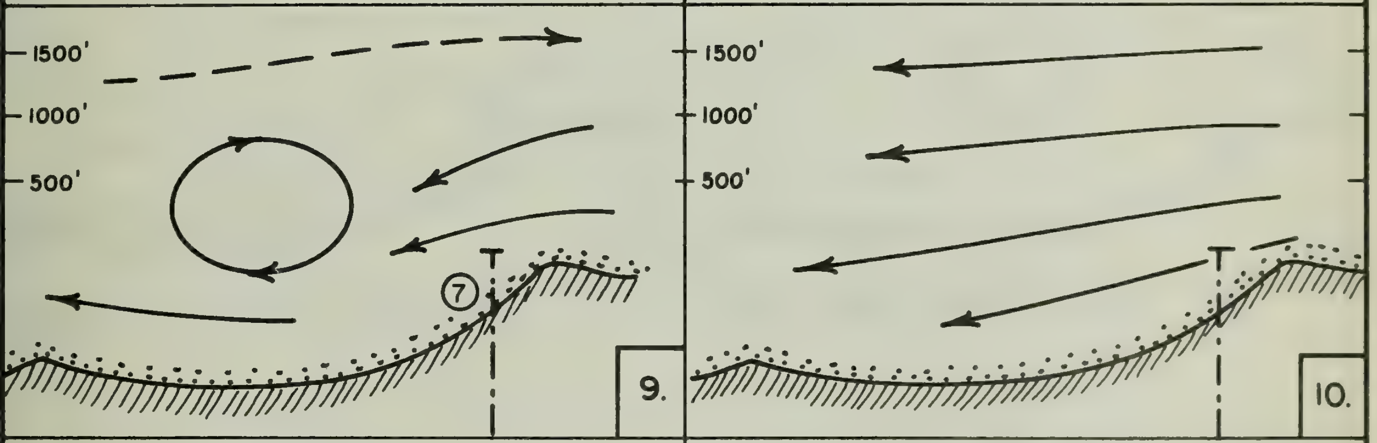
FIGURE VI-3(cont'd)

BAY-DELTA MODEL OBSERVATIONS OF TIDAL DYNAMICS IN PHASE I STUDY AREA



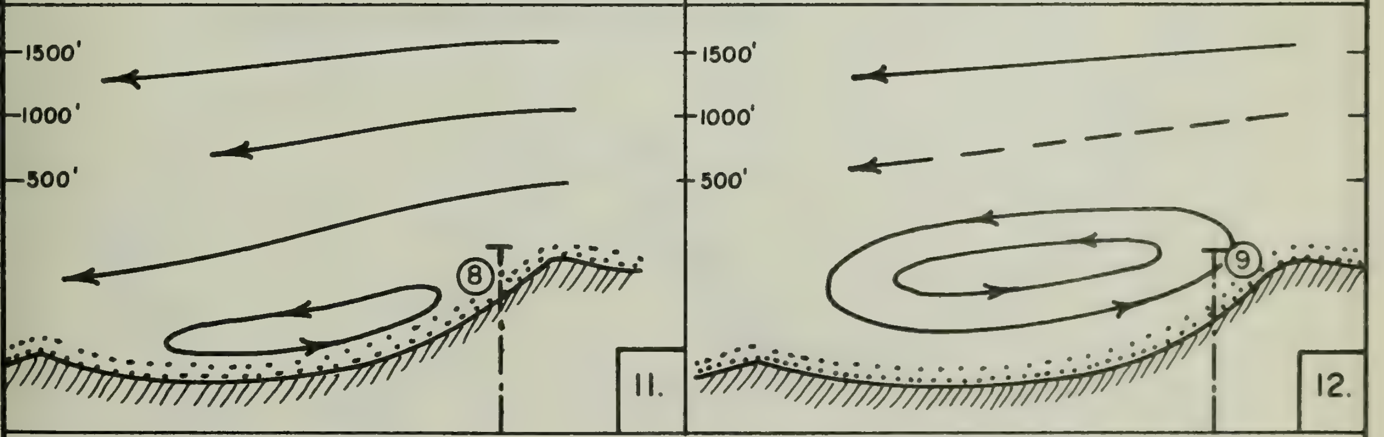
0800 CONTINUED SLACKENING

0930 EBB BEGINS AT B



1100 EBB INCREASES

1230 FULL EBB NO. 2

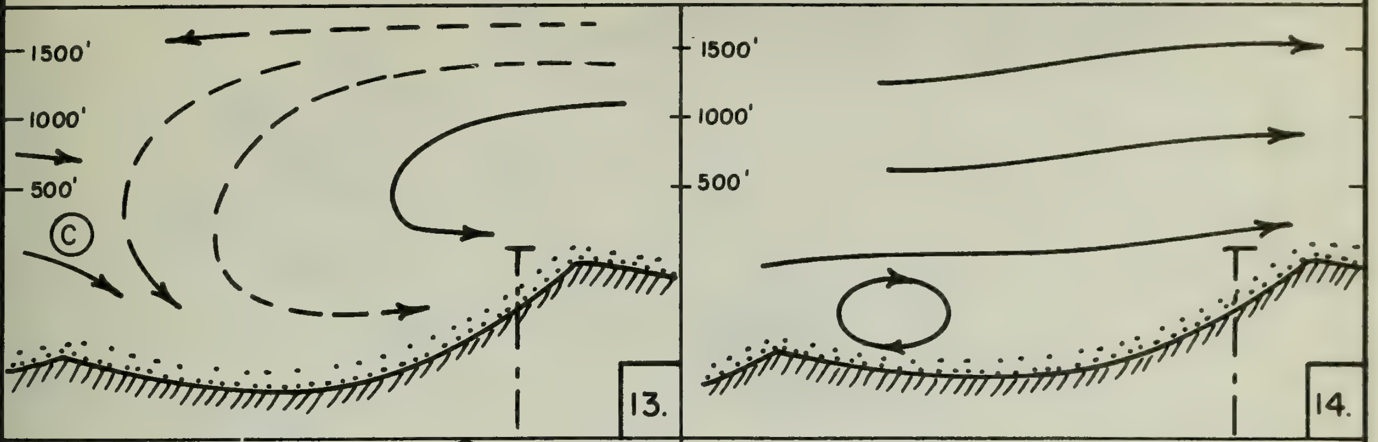


1400 EBB SLACKENING

1630 CONTINUED SLACKENING

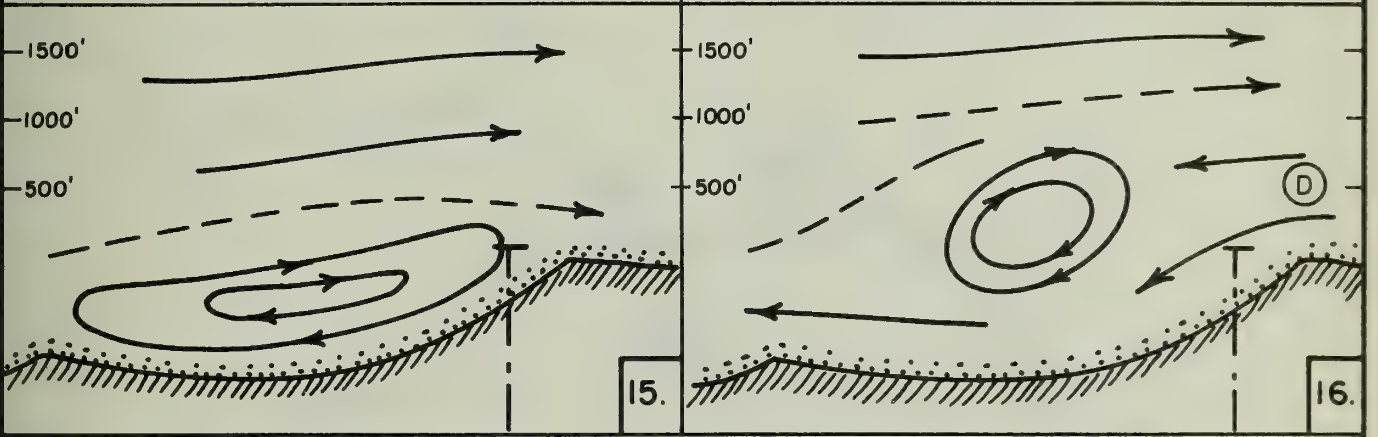
FIGURE VI-3(cont'd)

BAY-DELTA MODEL OBSERVATIONS OF TIDAL DYNAMICS IN PHASE I STUDY AREA



1730 FLOOD BEGINS AT Ⓒ

1830 EARLY FLOOD NO. 2



2030 CONTINUED SLACKENING

2230 EBB BEGINS AT Ⓓ

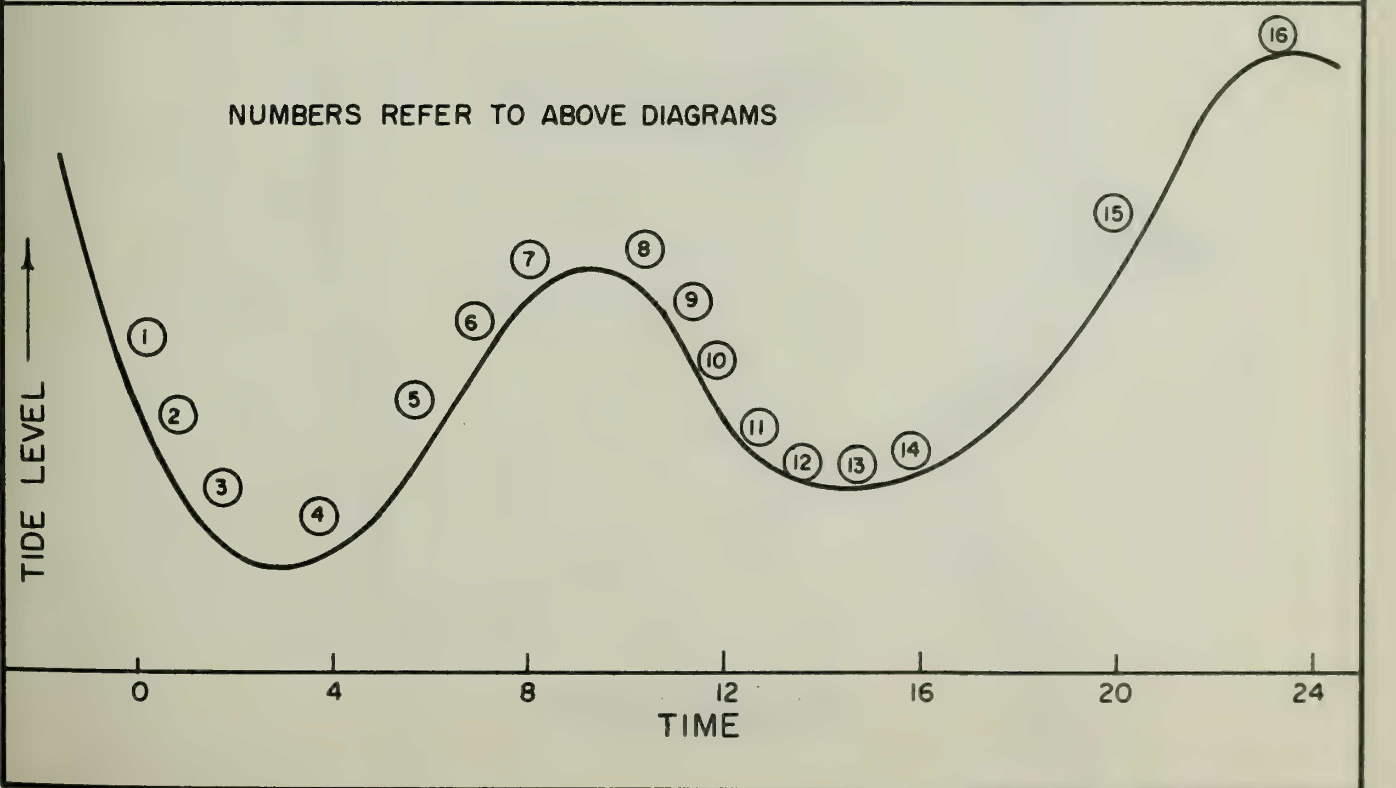
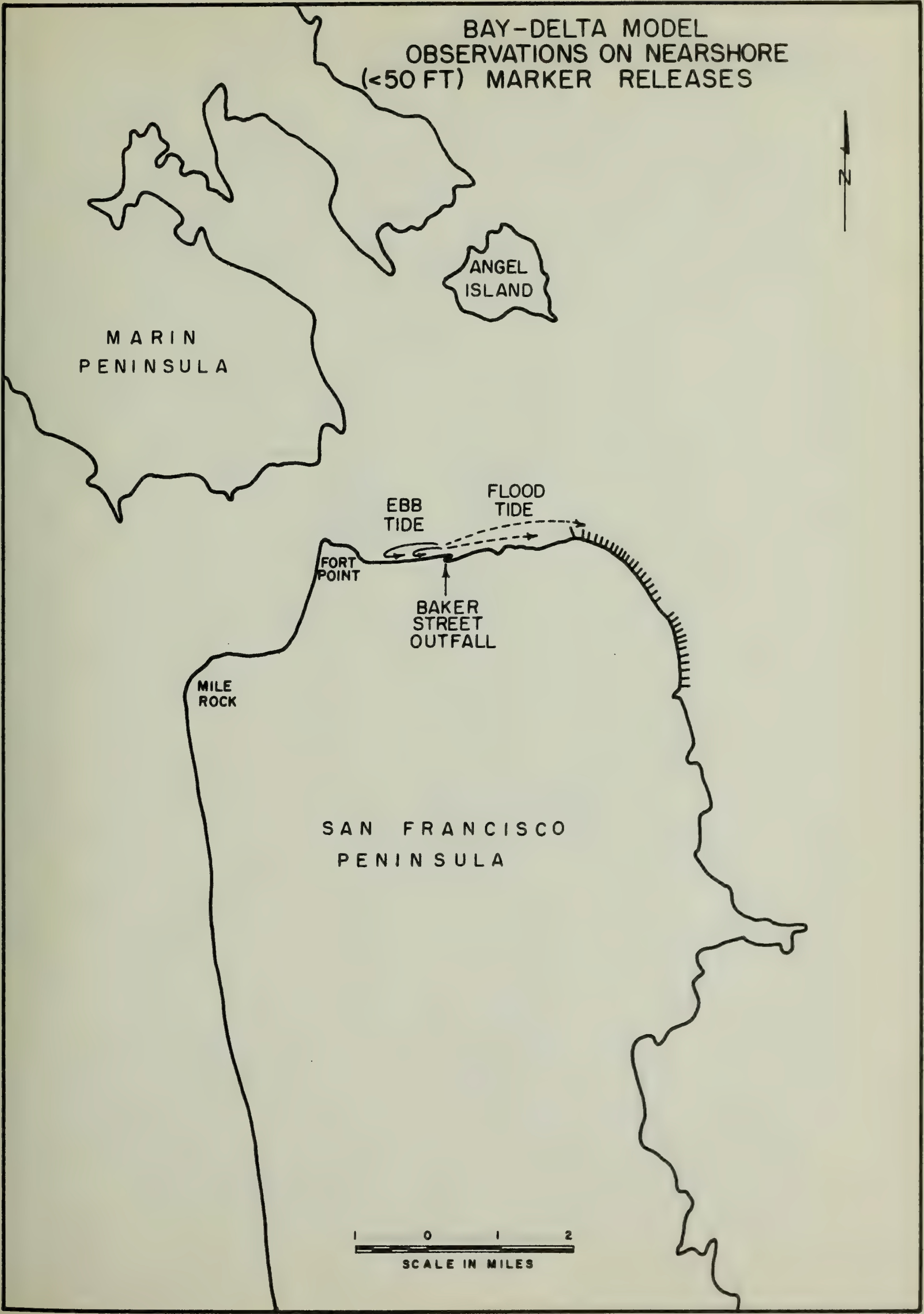


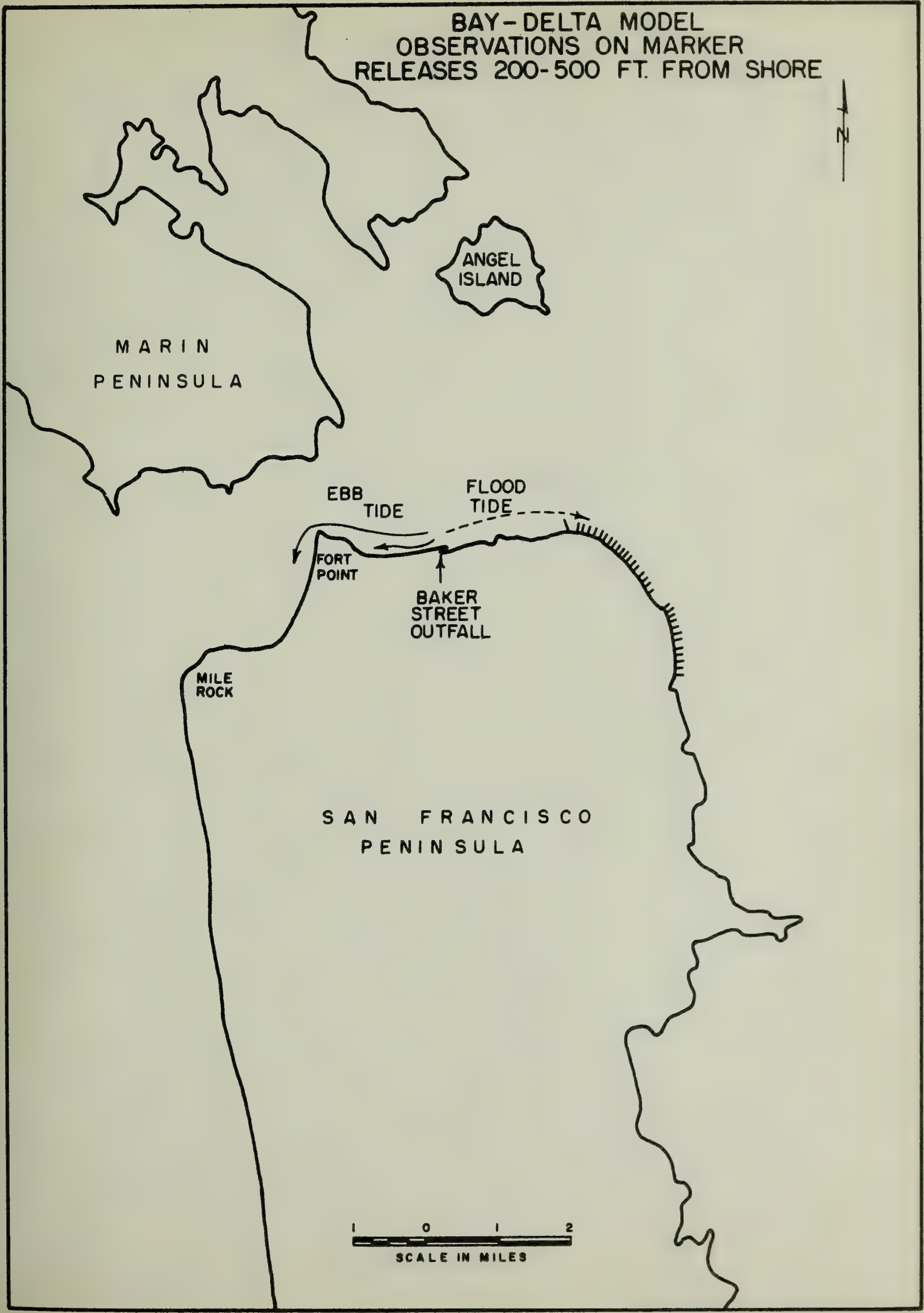
FIGURE VI-4



BAY-DELTA MODEL
OBSERVATIONS ON NEARSHORE
(<50 FT) MARKER RELEASES

ENGINEERING-SCIENCE, INC.

FIGURE VI-5



BAY-DELTA MODEL
OBSERVATIONS ON MARKER
RELEASES 200-500 FT. FROM SHORE

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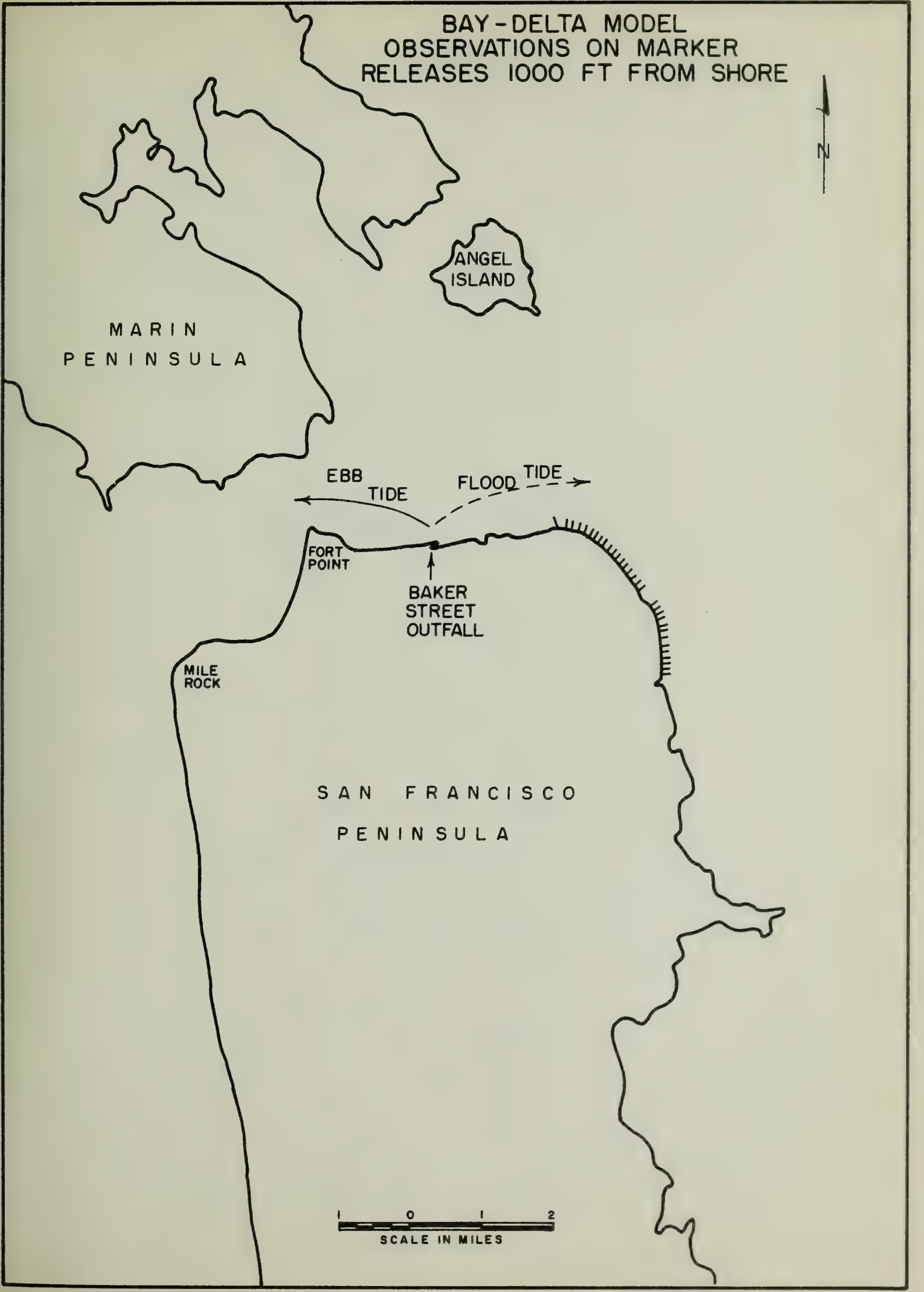
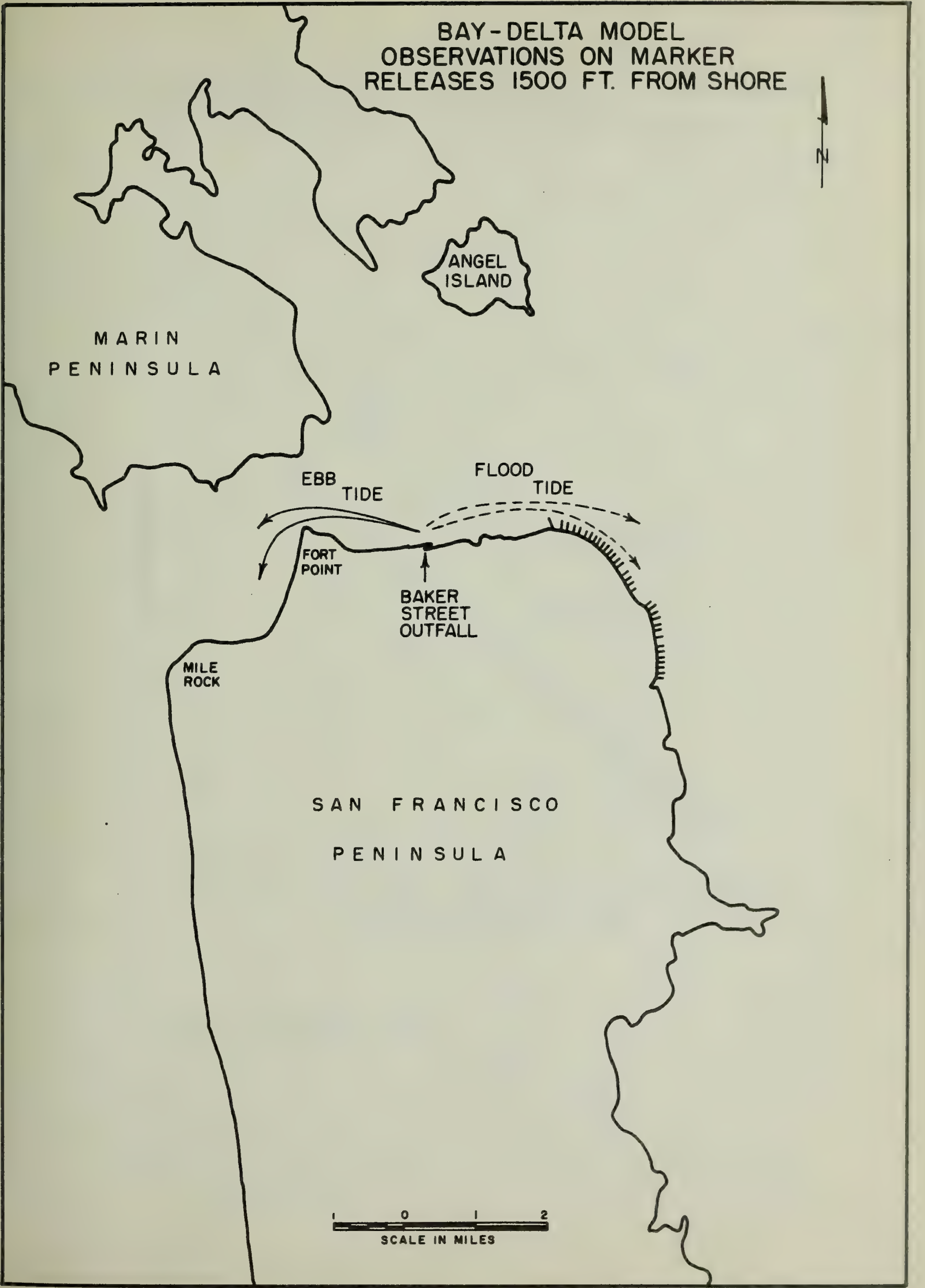
FIGURE VI-6

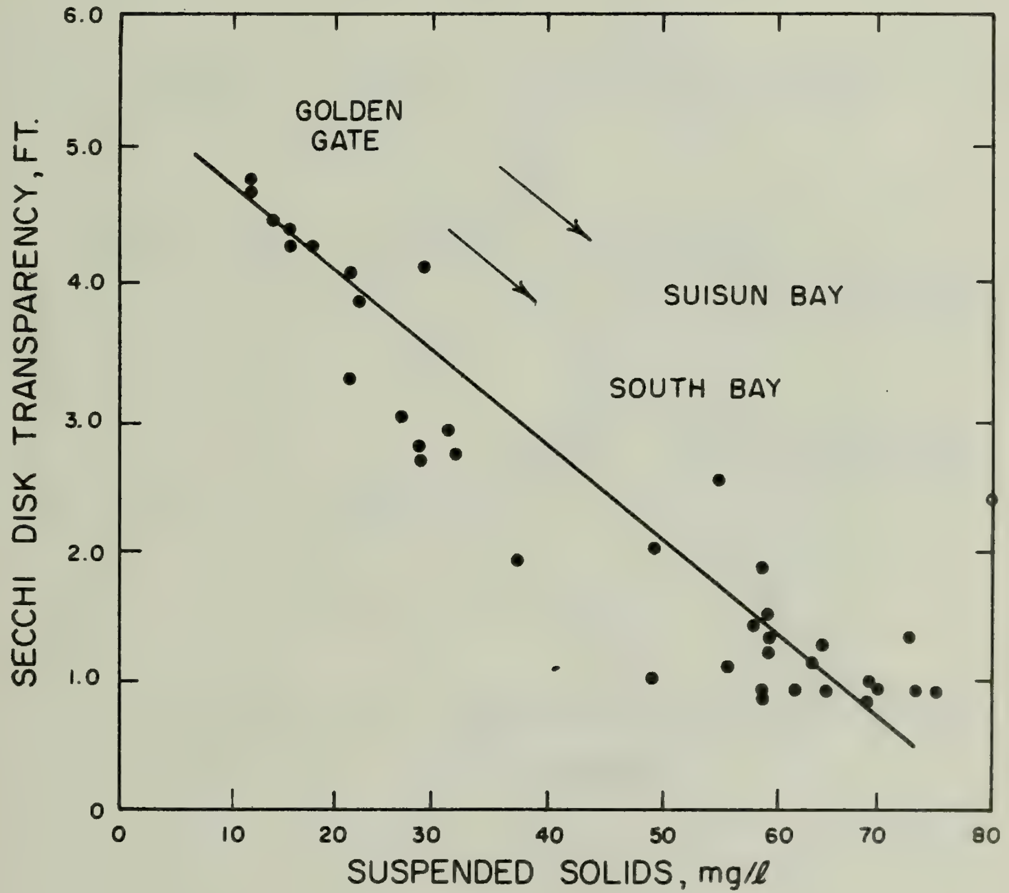


BAY-DELTA MODEL
OBSERVATIONS ON MARKER
RELEASES 1000 FT FROM SHORE



BAY-DELTA MODEL
OBSERVATIONS ON MARKER
RELEASES 1500 FT. FROM SHORE
N
ANGEL ISLAND
MARIN PENINSULA
EBB TIDE
FLOOD TIDE
FORT POINT
BAKER STREET OUTFALL
MILE ROCK
SAN FRANCISCO PENINSULA
1 0 1 2
SCALE IN MILES

RELATIONSHIP BETWEEN SUSPENDED SOLIDS AND SECCHI DISC TRANSPARENCY IN SAN FRANCISO BAY



SOURCE : REFERENCE VI-6

SEASONAL VARIATION OF MEAN TRANSPARENCY 1960-1964 SURVEYS OF UNIVERSITY OF CALIFORNIA (Reference VI-6)

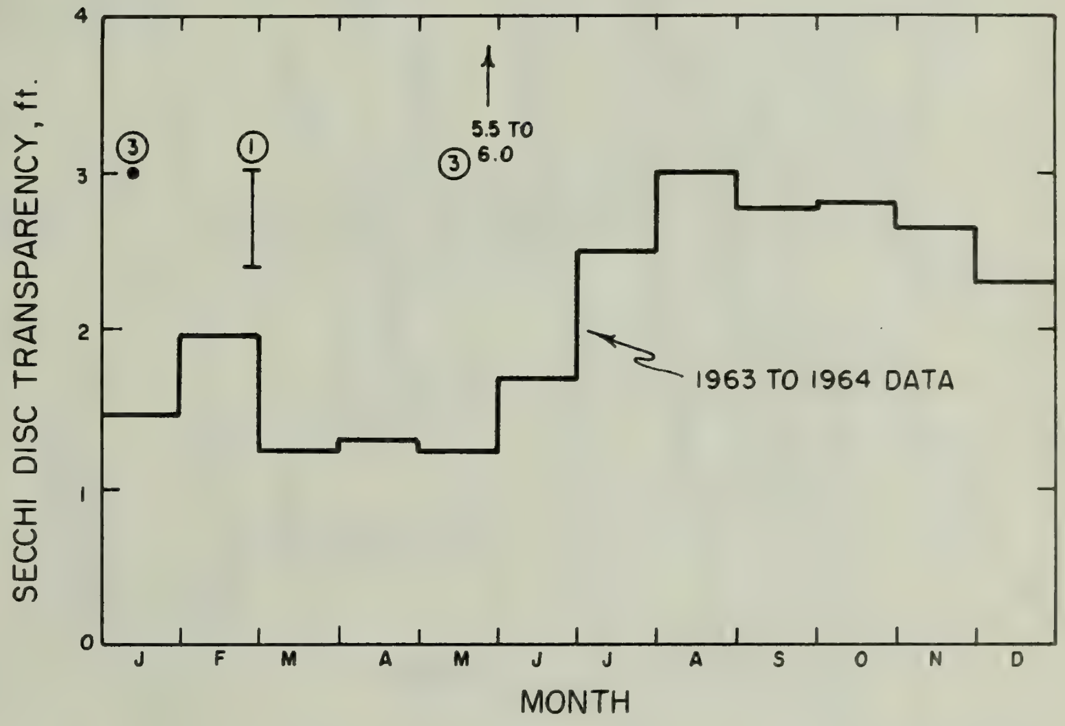
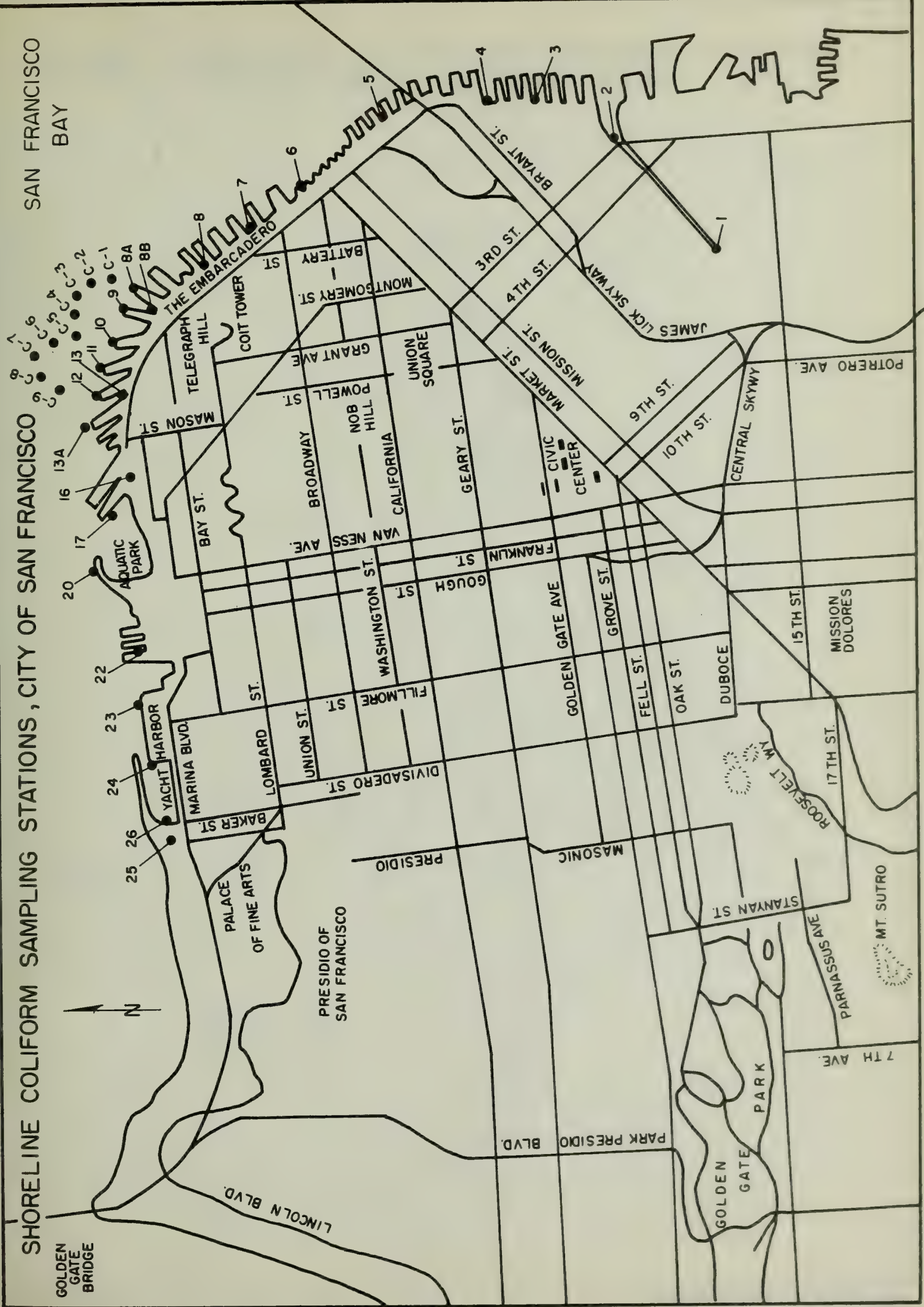


FIGURE VI-10



SHORELINE COLIFORM SAMPLING STATIONS, CITY OF SAN FRANCISCO

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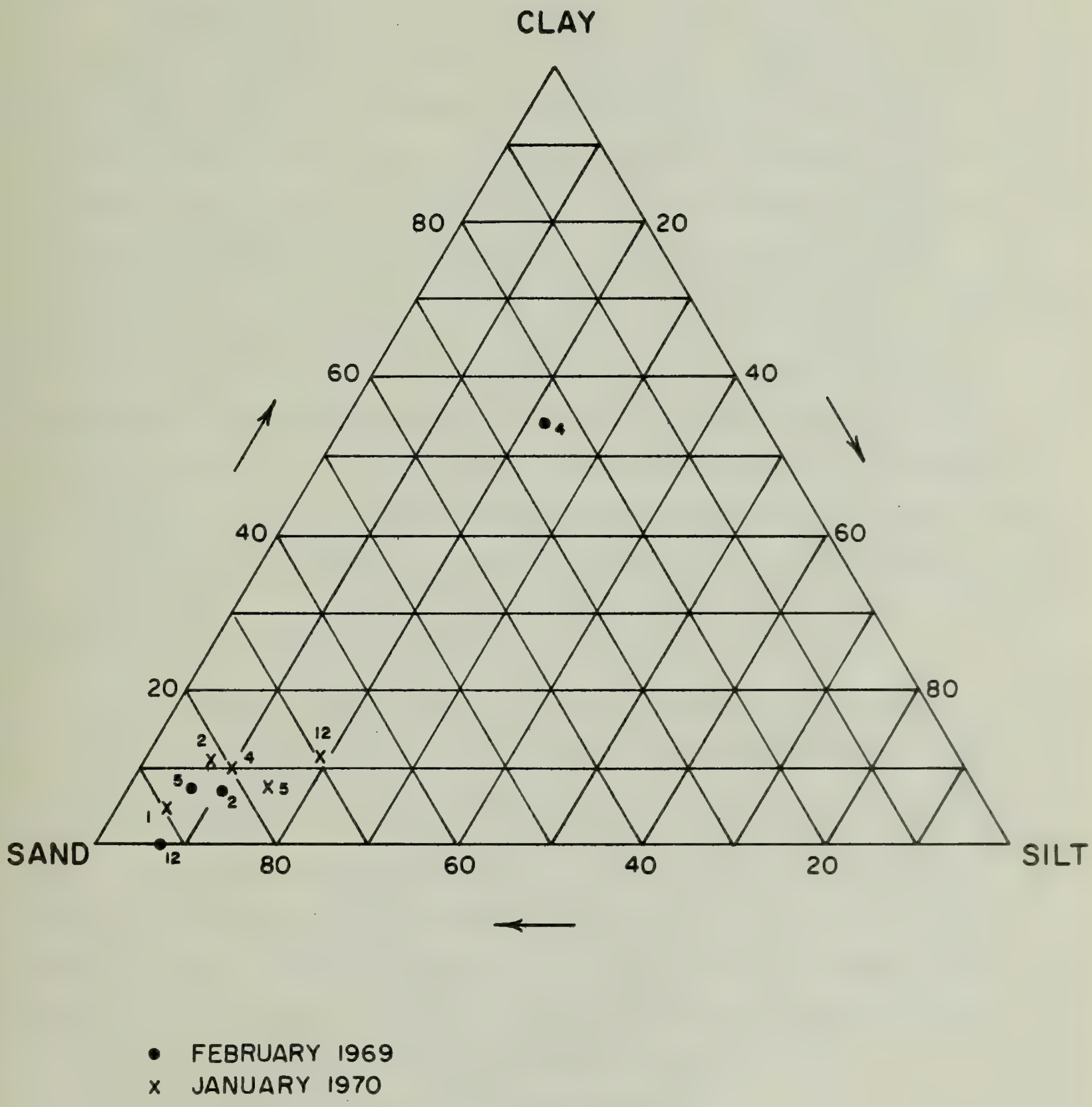
SEDIMENT COMPOSITION AT BENTHOS SAMPLING STATIONS
PHASE I RECEIVING WATER STUDY



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CHAPTER VII

DISCUSSION

INTRODUCTION

The wastewater emanating from urban areas can be categorized as either dry or wet weather flows. The former is comprised of the normal, or routine, sanitary wastewater generated within a sewer basin; whereas the latter is comprised of the dry weather flow and the wastewater produced as a result of surface runoff of storm waters and scour of the sewerage system, and are referred to as combined sewage flows. The management objectives for the wastewaters produced within an urban area complex are based necessarily on quality criteria established for the receiving environment. The operating options within a wastewater management program available to achieve the water quality criteria, with the exception of source reduction, are treatment or storage and treatment. Which of these two options or combination thereof is used in a particular management program is determined by the quantity and quality characteristics of the wastewaters and the temporal and spatial distribution of the occurrence of wastewaters of concern.

Dry weather flows, because of their continuing presence, constitute the reference circumstance for any urban area wastewater management program. With this type of reference it is then optional, within different frameworks of rationale, to consider the surface runoff wastewater component of combined sewage flows either as a problem supplemental to managing the dry weather flows or as a separate problem. When this option set is combined with the options for meeting the receiving water quality criteria, the management program alternatives for dealing with the combined sewage flows are:

- Supplemental problem using treatment.
- Supplemental problem using storage and treatment.
- Separate problem using treatment.
- Separate problem using storage and treatment.

There appear to be both philosophical and technical criteria for considering the above alternatives. The philosophical factors relate primarily to whether or not it is assumed that pollutants discharged to a receiving water in combined sewage overflows represent a different problem than pollutants discharged in treated dry weather flows. Also of interest is whether receiving water quality criteria are or should be different in type and restrictiveness for combined sewage relative to dry weather discharges. Whether such conceptual distinctions between dry and wet weather flows are meaningful would seem to depend on variations in dry and wet weather beneficial uses of the receiving water and on the time required for the wet weather receiving water condition to revert to dry weather conditions following the cessation of wet weather climatic conditions.

The technical factors affecting the selection of management alternatives can be evaluated in terms of the economics associated with achieving a selected or alternative receiving water quality criteria. Inasmuch as the problem of how to evaluate marginal incremental benefits of wastewater management has not been resolved, one can consider only the least cost system to realize specified water quality criteria. In this sense it is important to note that dividing a system into two subsystems and determining the least cost solution for each subsystem does not necessarily ensure the least cost solution for the total system. Thus, if the dry weather flows and the combined sewage flows, or the portion thereof, in excess of the dry weather flows are considered as separate problems in one set of alternate management programs, then the sum of the two least cost solutions will not necessarily provide the least cost solution for the management of all the wastewaters.

In order to assess the economic aspects of the management alternatives listed above, it is necessary to develop the technical information and approaches requisite to evaluating the extent and characteristics of the different types and components of wastewater flows. The data and information developed during the course of this study have been evaluated in a manner such that it can be used to gain insight relative to the implications of the different wastewater management program alternatives.

EVALUATION OF DRY WEATHER AND COMBINED SEWAGE WASTEWATER LOADS

As described in Chapter V, the data obtained in the course of the study have been used to develop an approach for characterizing dry weather and combined sewage flows derived from different land use areas in the City. The approach provides a basis for determining the magnitude of the dry weather and combined sewage wastewater flows as well as for ascertaining the pollutant mass emission coefficients for the two categories of wastewaters. The net, or due-to-storm, mass emission coefficients developed during the course of the study make it possible to estimate the quantity of pollutant produced on a per storm basis as a result of the surface water runoff and sewer system scour. With these tools both the dry weather and storm water runoff pollutant contributions can be estimated and specific alternative schemes for management of the total wastewater or either wastewater component can be assessed.

The scope of the present study was limited to evaluation of quantity and quality relationships for combined sewer overflows and the impact of the wet weather discharges at Outer Marina Beach. Within these perspectives the coefficients were used to evaluate two questions of importance in selecting dry and wet weather wastewater management alternatives:

(1) To develop a per-storm comparison between estimated dry weather and combined sewage pollutant emissions and dry and wet weather receiving water quality as a basis for evaluating the immediate impact of combined sewage emission on receiving water quality.

(2) To permit a comparison on an annual basis of the relative magnitude of pollutant emissions from dry weather and combined sewage flows, assuming various levels of treatment in each case, in order to provide an overall basis for evaluating the mass of pollutant removed as a function of where treatment is provided.

Wastewater Emissions and Receiving Environment Quality During Dry and Wet Weather Receiving Water Surveys

In order to evaluate the immediate impact of wet weather wastewater emissions on receiving water quality, the receiving water quality

data developed from the three surveys described in Chapter VI were used as reference information, and the dry weather and due-to-storm coefficients were used to estimate wastewater emissions on the day of, and for several days preceding, each of the receiving water surveys.

In this example application of the coefficients, the following conditions were considered:

(1) There is an implication that the quality of the receiving environment at Outer Marina Beach may be related to the magnitude of wastewater emissions to the Bay system during wet weather. For the application examples a comparison of dry weather and combined sewage wastewater emissions was developed using the coefficients to estimate the treated dry weather, treated storm runoff, and bypassed (untreated) combined sewage wastewater emissions from the North Point and Southeast Drainage Districts of the City.

(2) Dry weather wastewater emissions from these districts were estimated on the basis of the population and treatment plant efficiency characteristics reported in Table VII-1 for three parameters: TSS; HEM; and floatable materials.

(3) Storm runoff wastewater emissions were estimated with Equations V-2 (TSS), V-5 (HEM), and V-6 (floatable materials) and an assumed composite runoff factor of 70 percent for the North Point and Southeast districts. It was then assumed that the combined sewage generated by the initial 0.02 in. of rainfall was diverted to the dry weather system and subjected to treatment at the sewage treatment facility at the same efficiency level as the dry weather flow before discharge to the receiving system.

(4) The total wet weather wastewater emissions were estimated as the sum of the treated dry weather emissions, treated storm runoff emissions (from the initial 0.02 in. of rainfall), and bypassed combined sewage emissions.

(5) The rainfall data used in the example were obtained from the station at the Federal Office Building in San Francisco; it is assumed that these rainfall levels also occurred in the North Point and Southeast Drainage Districts.

TABLE VII-1

APPLICATION EXAMPLE

ESTIMATED DRY WEATHER WASTEWATER EMISSIONS FROM NORTHEAST AND SOUTHEAST DRAINAGE BASINS, SAN FRANCISCO

District	Estimated Population	Land Area	Dry Weather Mass Emission Coefficients (pcd)[1]			Dry Weather Wastewater Emissions (10^3 lb/day)[2]		
			TSS	HEM	Floatable Materials	TSS	HEM	Floatable Materials
North Point	400,000	9,000	0.173	0.040	0.0025	69,200	16,000	1,000
Southeast	175,000	7,100	0.165	0.029	0.0025	28,000	5,100	440
Treated Dry Weather Emissions from Both Basins						48,600	15,800	720

NOTES: [1] Laguna Street coefficients used for North Point Drainage District, and Selby Street coefficients used for Southeast Drainage District (Table V-1).

[2] Treated dry weather emissions based on following removal efficiencies for primary treatment:

TSS: 50%
HEM: 25%
Floatable materials: 50%

A summary of the estimated total emissions of TSS, HEM, and floatable and coliform MPN levels during the three receiving water surveys is presented in Table VII-2. The rainfall averaged 0.30 in./day on the three days preceding the first wet weather receiving water survey (24-25 February 1969) and 0.25 in./day on the three days preceding the second wet weather survey (9-10 January 1970). The dry weather survey was conducted on 26-27 May 1969.

As reported in Table VII-2, the estimated total emissions of TSS, HEM, and floatable materials were from two to six times greater during wet weather than during dry weather. Between dry and wet weather conditions the observed particulate floatables in the receiving water increased by one to two orders of magnitude and the surface density of HEM was found to increase by three to four orders of magnitude. The median fecal coliform MPN levels were found to be 10 to 15 times higher, and the median total coliform MPN were observed to be seven to 23 times higher during wet weather relative to dry weather conditions. Similarly, the HEM content of beach sediments was found to increase by an average of three to four times between dry and wet weather conditions (Table VII-2). It is apparent from the foregoing that a positive correlation exists between the magnitude of wastewater emissions during dry and wet weather (as estimated herein) and the observed receiving environment quality. That is, a 200 to 600 percent increase in estimated wastewater emissions during a rainy season was associated with order-of-magnitude increases in levels of receiving water characteristics.

The scope of the present study did not permit the field evaluation of the time required for wet weather receiving environment quality to revert to dry weather conditions following the cessation of rainfall. As reported in Appendix A, an evaluation of coliform MPN data at Outer Marina Beach indicates that the magnitude of this parameter decreased from mean wet to dry weather levels in less than five dry-weather days after a rainy day, reflecting the natural capacity of the Bay system to attenuate and/or disperse pulse inputs of organisms of sewage origin. If the rate of decay of coliform MPN level to dry weather conditions is also representative of other parameters affecting the beneficial

TABLE VII-2

APPLICATION EXAMPLE

ESTIMATED DRY AND WET WEATHER WASTEWATER EMISSIONS AND RECEIVING ENVIRONMENT QUALITY

Date	Rainfall (in.)	Estimated Total Wastewater Emissions- Dry and Wet Weather[1] (lb/day)			Observed Receiving Environment Quality			
					Particulate Floatables		Median Coliform (MPN/100 ml)	
		TSS	HEM	Floatable Materials	mg/sq m	% HEM	Total	Fecal
20 Feb 1969	-	48,600	15,800	720				
21 Feb 1969	0.29	308,000	32,800	3,230				
22 Feb 1969	0.21	307,000	31,800	3,170				
23 Feb 1969	0.40	311,000	34,400	3,360				
24 Feb 1969	0.63	314,000	35,300	3,330	10.5	-	910	360
25 Feb 1969	0.27	308,000	32,500	3,270				
26 May 1969	-	48,600	15,800	720	0.55	< 0.01	140	35
27 May 1969	-	48,600	15,800	720				
6 Jan 1970	-	48,600	15,800	720				
7 Jan 1970	0.03	293,000	20,800	2,490				
8 Jan 1970	0.18	301,000	30,400	3,140				
9 Jan 1970	0.57	313,000	35,600	3,330				
10 Jan 1970	-				10.5	2.2	3,200	500

NOTE: [1] Sum of treated dry weather, treated stormwater runoff, and bypassed combined sewage wastewater emissions.

uses of the receiving water (such as particulate floatables), it is apparent that the number of days on which water quality will be impaired by wet weather emissions is a function of the discrete time intervals between storm patterns as well as the time span between the initial and final rainfalls of the season.

Estimated Annual Dry Weather and Combined Sewage Wastewater Emissions

The total dry weather and combined sewage emissions were estimated for a single drainage basin (Baker Street) by cumulating estimates of the per-storm combined sewage emissions occurring over a historical rainfall pattern and estimates of dry weather wastewater emissions. This application example is not based on an entire annual record of rainfall, but rather on a time period (1 October to 15 December 1969, which represents 21 percent of a year) during which a total of 4.52 inches of rainfall (or 22 percent of normal rainfall) was recorded at the Federal Office Building raingauge of the United States Weather Bureau.

It is assumed for the purposes of this example that the rainfall record observed at the Federal Office Building (Table VII-3) also occurred throughout the Baker Street basin. Because the time interval is approximately the same portion of a year as is the rainfall of the total annual rainfall, the conditions calculated for this period were assumed to be representative of conditions on an annual basis. Storms exhibiting intensities in excess of 0.02 in. per hour occurred for a total of 56 hours during the total time of 2.5 months, or about three percent of the time. For the assumption that the bypass of combined sewage flow occurred only at or above this rainfall intensity, bypasses would have occurred on an average of three percent of the time on an annual basis. Based on the information summarized in Table V-3, a runoff factor of 75 percent was used for the Baker Street basin. Storm runoff pollutant emissions were calculated using the storm runoff mass emission equations presented in Chapter V (Equations V-1 to V-6). Dry weather flows and mass emissions were calculated for the time interval using the coefficient for Baker Street reported in Table V-1 and the Baker Street basin population equivalent of 13,200 (Table IV-1).

TABLE VII-3

APPLICATION EXAMPLE
STORMS IN SAN FRANCISCO-
1 OCTOBER TO 15 DECEMBER 1969

Date of Storm (1969)	Interval Between Storms (days)	Total Precipitation (in.)	Storm Duration @ Intensities >0.02 in./hr (hours)
8 October	2	0.07	3
10 October	4	0.13	6
14 October	0	0.07	2
15 October	1	2.29	16
16 October	19	0.05	1
5 November	1	0.41	6
6 November	1	0.03	1
7 November	30	0.01	0
8 December	1	0.56	7
9 December	1	0.01	0
10 December	1	0.70	8
11 December	1	0.10	3
12 December	1	0.08	3
13 December	1	0.01	0

NOTES: (1) Total Precipitation: 1 October to 15 December: 4.52 inches.

(2) Source: United States Weather Bureau, Federal Office Building, San Francisco.

The portion of the combined sewage flow that was diverted to the dry weather system during the time period used in the example was estimated as that resulting from the initial 0.02 in. per hour of rainfall. It was assumed that combined sewage flows generated by rainfalls in excess of 0.02 in. per hour were bypassed to the receiving system without treatment; in the present example, the latter circumstance occurred three percent of the time.

The results of the above calculations are shown in Table VII-4 and indicate that a total storm runoff of 3.71 inches, total COD emission of 19,540 lbs, and a total TSS emission of 43,770 lbs occurred due to storm water runoff during the 2.5 month period. These data were combined with the dry weather flows and mass emissions to determine the untreated mass emissions from dry weather flows, storm runoff, and wet weather bypasses on a lb per acre-year basis as presented in Table VII-5.

The untreated total mass emission calculated to have occurred during the 2.5 month period of the example includes 9,620 lb/acre-year of COD and 5,260 lb/acre-year of TSS, as reported in Table VII-5. About 90 percent of the total flow and COD over 95 percent of the TN, OPP, and HEM, and over 75 percent of the TSS and floatables in the total annual flow would be derived from the dry weather component. Storm runoff contains, per unit of COD, about 5, 0.8, 0.4, 0.5, and 3 times the TSS, TN, OPP, HEM, and floatables, respectively, found in dry weather flows.

In reference to combined sewage overflows, it is estimated that nine percent of the COD, 26 percent of the TSS, and 16 percent of the floatable emissions generated on an annual basis in the Baker Street basin would be bypassed to the receiving waters. The effect of dry weather flows on the quality of combined sewage overflows is evident from a comparison of the pollutant mass emission of combined sewage overflows and storm runoff. The combined sewage overflows would transport to the receiving water 100 percent more OPP and HEM, 50 to 60 percent more COD and TN, 20 percent more floatables, and eight percent more TSS than would the surface runoff contribution to the bypass (Table VII-5).

The combined sewage overflow is estimated to equal about 15 percent, or one-sixth, the dry weather flow. Thus, it is apparent, based on this

TABLE VII-4

APPLICATION EXAMPLE
ESTIMATED RUNOFF AND POLLUTANT EMISSIONS DUE TO STORMS IN BAKER STREET DRAINAGE BASIN
1 OCTOBER TO 15 DECEMBER 1969

Date of Storm (1969)	Runoff$^{(1)}$ (in.)	Total Pollutant Emissions (lbs) Due-to-Storm					
		COD	TSS	TN	OPP	HEM	Floatable Materials
8 October	0.05	1,650	3,970	83	13.8	118	33.1
10 October	0.10	1,830	4,000	91	15.3	178	36.7
14 October	0.05	1,650	3,970	83	13.8	118	33.1
15 October	1.72	2,010	4,030	100	16.8	353	40.3
16 October	0.04	1,610	3,930	80	13.4	98	32.2
5 November	0.64$^{(2)}$	1,990	4,030	99	16.5	311	39.8
6 November	0.02	1,370	3,830	68	11.4	53	27.4
8 December	0.42	1,960	4,020	97	16.4	286	39.3
10 December	0.53	1,980	4,020	98	16.5	299	39.6
11 December	0.08	1,790	3,990	89	15.0	159	35.9
12 December	0.06	1,700	3,980	86	14.3	133	34.2
TOTAL	3.71	19,540	43,770	974	163.2	2,106	391.6

NOTES: (1) Estimated runoff factor for Baker Street Drainage Basin: 75 percent; area of basin, 168 acres.

(2) Datum from Table V-3.

TABLE VII-5

APPLICATION EXAMPLE
COMPARISON OF MASS DISCHARGES
FROM BAKER STREET DRAINAGE BASIN

Constituent	Untreated Mass Emissions (lb/acre-year)				Untreated Mass Emissions (% of total)		
	Dry Weather Flow	Storm Runoff	Total	Combined Sewage Overflow	Dry Weather Flow	Storm Runoff	Combined Sewage Overflow
COD	9,060	560	9,620	830	94	6	9
TSS	4,020	1,240	5,260	1,360	76	24	26
TN	565	28	593	45	95	5	8
OPP	179	4	183	9	98	2	5
HEM	1,750	60	1,810	112	97	3	6
Floatable Materials	56	11	67	11.2	84	16	19
Average Flow (cfs/acre)	0.0157	0.0020	0.0177	0.0025	88	12	15

NOTE: Combined sewage overflow calculated as the sum of three percent of any dry weather and storm runoff discharges.

example, that the combined sewage overflow would contain significantly more HEM, OPP, COD, and TN than would storm runoff, and that the dry weather contribution of floatable materials and TSS to the combined sewage overflow is much less significant.

An assessment of the effect of primary and secondary waste treatment alternatives, based on the information of this example, on the total annual mass discharges from the Baker Street drainage basin is summarized in Table VII-6. Included are alternatives dealing with primary and secondary treatment of dry weather flows, and primary treatment of combined sewage overflow. Several implications about treatment of the waste flows follow from these alternatives:

(1) The principal benefits of primary treatment of the total flow as compared with dry weather flow only would be derived from increased removals of TSS (approximately 30 percent) and floatables (approximately 20 percent), both constituents being associated with the esthetic character of waste discharges. Total flow primary treatment would increase total COD, TN, and HEM removal by about 10 percent over the situation in which the same level of treatment of dry weather flow only would be provided.

(2) Secondary treatment of dry weather flow only would be significantly more effective than total flow primary treatment; from two to three times more COD, TN, OPP, and HEM and about 1 and 1/2 times more TSS and floatables would be removed by the former method in comparison with the latter.

(3) The untreated combined sewage overflow component of the total load is similar in magnitude to the fraction of the dry weather flow not removed by secondary treatment of the dry weather flow. About 11 percent of the COD, six percent of the HEM, and 16 percent of the floatables in the total mass emissions remain after secondary treatment of the dry weather flow; in comparison, the combined sewage overflow contains nine percent of the COD, seven percent of the HEM, and 19 percent of the floatables. Percentages of suspended solids are noticeably higher, and percentages of total nitrogen and orthophosphate-phosphorus significantly lower, in the combined sewage overflows relative to what

TABLE VII-6

APPLICATION EXAMPLE

EFFECT OF WASTE TREATMENT ALTERNATIVES ON TOTAL ANNUAL MASS DISCHARGES FROM BAKER STREET DRAINAGE BASIN

Constituent	% Removal by Treatment		Total Annual Untreated Mass Emission (lb/acre-year)	% Reduction in Total Effected By				Untreated Combined Sewage Overflow (% of total flow emissions)
	Primary	Secondary		Primary Treatment Dry Weather Flows	Primary Treatment of Total Flow	Secondary Treatment Dry Weather Flows	Secondary for DWF Primary for CSO[1]	
COD	35	90	9,620	32	35	84	87	9
TSS	50	95	5,260	37	50	72	85	26
TN	10	20	593	9	10	19	20	8
OPP	5	15	183	5	5	15	15	5
HEM	25	95	1,810	23	25	92	93	6
Floatable Materials	50	90	67	41	50	76	84	19

NOTE: [1] Secondary treatment for dry weather flows and primary treatment for combined sewage overflows.

the estimated dry weather emission to the receiving system would be after secondary treatment.

The above application examples serve to illustrate the utility of the due-to-storm mass emission coefficients in determining the specific nature of the wastewater management problems existing in any selected drainage basin. That is, for the example: the untreated combined sewage overflows contained less than 10 percent of the COD, OPP, TN, and HEM, less than 20 percent of the floatables, and about 25 percent of the TSS in the calculated total annual wastewater generation in the basin; the emissions due to the untreated combined sewage overflow component, under the conditions of the example, are similar in magnitude to those estimated for discharge of the dry weather flow after secondary treatment. The above method of analysis, for any given set of historical rainfall data and diversion level, can be used to rapidly place in perspective the total wastewater management problems of a drainage basin and identify orderly treatment priorities required to achieve water pollution control.

EVALUATION OF COMBINED SEWAGE, STORM SEWAGE, AND RECEIVING WATER QUALITY

Present Water Quality Objectives

The San Francisco Bay Regional Water Quality Control Board has established the beneficial uses of the Bay receiving waters contiguous to the Outer Marina Beach at Baker Street as follows (Reference VII-1):

(1) Swimming, wading, pleasure, boating, marinas, launching ramps, fishing, and shellfishing.

(2) Industrial cooling water.

(3) Fish, shellfish and wildlife propagation and sustenance, and waterfowl and migratory bird habitat and resting.

(4) Navigation channels and port facilities.

(5) Esthetic enjoyment.

In order to protect these benefits the Regional Board has formulated waste discharge and receiving water quality requirements (Reference VII-1)

which are applicable to all combined sewage discharges.

The following requirements are of concern with respect to the quality of combined sewage flow:

(1) All waste discharges shall meet the following quality limits in any grab sample:

(a) Grease, 25 mg/l maximum.

(b) Settleable matter, 1.0 ml/l/hr maximum.

(2) All waste discharges shall meet these quality limits in any representative sample:

(a) Toxicity, survival of test fish in 96-hr bioassays of the waste as discharged.

(1) Any sample, 75 percent minimum.

(2) Average of any three of more consecutive samples collected during any 21 or more days, 90 percent.

(b) pH, 7.0 minimum and 8.5 maximum.

The following receiving water requirements are of concern:

(1) None of the discharges shall cause unreasonable effects to any of the protected beneficial uses resulting from (a) floating, suspended, or deposited macroscopic particulate matter, oil, or grease in water of the State at any place; (b) bottom deposits at any place; and (c) floatables, color, or turbidity more than 400 ft from the Baker Street outfall.

(2) None of the discharges shall cause bacterial concentrations in waters of the State at any place within one foot of the surface to exceed a median value of 240 MPN coliform per 100 ml, as determined in any five consecutive samples collected at any one station, or any single sample to exceed an MPN coliform concentration of 10,000/100 ml at any time.

Present Combined and Storm Sewage Quality

The results of the combined and storm sewage monitoring program provide a basis for comparing the observed levels of toxicity, pH,

settleable solids, and grease in these streams with the levels specified in the RWQCB requirements. A summary of the toxicity bioassay results has been presented in Table V-6. Twelve of the 13 combined sewage samples and two of the four storm sewage samples had toxicity levels (96-hr percent survival levels) that are within the quality limits of the requirements. While additional information is needed to indicate conclusively the toxicity characteristics of these streams, it is apparent that the combined and storm sewage flows do not pose a toxicity problem relative to the current RWQCB requirements.

A summary of the pH, settleable solids, and grease data for combined and storm sewage flows monitored in the present and 1966-1967 studies is presented in Table VII-7. Each parameter is reported in terms of the ranges of values observed and the percent of the discrete observations which were outside of the RWQCB quality limits. Several trends can be observed from these data:

(1) Over 50 percent of the pH values observed in the combined sewages and all pH values observed in the storm sewages were outside of RWQCB quality limits (7.0 to 8.5).

(2) Over 80 percent of the settleable solids levels in the combined sewages and 30 percent of the settleable solids levels in the storm sewages were in excess of the RWQCB limit of 1.0 ml/l/hr.

(3) None of the grease levels observed in the storm sewages and 10 to 50 percent of the grease levels observed in the combined sewages were in excess of the RWQCB limit of 25 mg/l.

The present significance of the pH problem identified above is unknown with respect to impact on receiving water quality. However, it is apparent that the settleable solids and grease concentrations in the combined sewages monitored in the two studies pose significant problems with respect to the RWQCB limits and that the storm sewages are a problem area to a lesser extent and only with respect to the settleable solids limit.

Present Receiving Water Quality

The findings of this study indicate that the hydrodynamic regime

TABLE VII-7

SUMMARY OF COMBINED AND STORM SEWAGE QUALITY LEVELS

Drainage Basin	Characteristic (Range and % of observations outside of RWQCB quality limits)					
	pH		Settleable Solids (ml/l/hr)		Grease (mg/l)	
	Range	%	Range	%	Range	%
Combined Sewage						
Baker Street	6.6-7.4	50	1.0- 5.5	81	0.1- 110.3	12
Mariposa Street	1.9-9.1	55	1.0- 38.0	93	0.8-1,327.0	47
Brotherhood Way	6.3-7.9	66	0.2- 32.0	90	3.1- 423.0	21
Selby Street	-	-	0.6-290.0	78	0.4- 120.5	32
Laguna Street	-	-	4.0- 80.0	100	2.2- 63.4	54
Storm Sewage						
Vicente St (Area 1)	6.4-6.7	100	0.2- 11.4	33	4.5- 17.9	0
Vicente St (Area 2)	6.1-6.8	100	0.1- 10.5	37	6.6- 21.5	0

operative in Central San Francisco Bay results in the formation of longshore currents beyond about 500 ft offshore which move into the Bay system during flood tide and which reverse and move out of the Bay during ebb tide. Observations on the Bay-Delta Model of the United States Army Corps of Engineers indicate that counterclockwise eddies form during ebb slackening, and clockwise eddies during flood slackening, in the zone from 500 ft offshore to the shoreline at Outer Marina Beach. No effort could be made to document the extent and duration of these eddies in the field program of this study; however, because both the existing and new Baker Street outfalls discharge to the zone in which the eddy patterns were indicated, there is a need for more detailed study of circulation patterns in the nearshore receiving waters in conjunction with the post-evaluation studies.

While there is at present only limited definition of current patterns in the nearshore zone (0 to 1,000 ft offshore) at Outer Marina Beach, considerable implication exists that the quality of these receiving waters is controlled by upstream waste discharges. The ebb tide transports significant quantities of diluted treatment plant effluents and combined storm sewage flows from the southern estuary of the Bay past the northeasterly shore of San Francisco toward the ocean. The effect of upstream discharges is apparent from an analysis of coliform MPN levels at Station No. 25 (St. Francis Yacht Club) at incoming and outgoing tidal current stages in wet weather. The data used for the analysis were developed between July 1966 and December 1968 (after chlorination had been implemented at all major Bay discharges). A three-fold difference was observed between mean coliform MPN levels at ebb-low slack tidal current stage (3.4×10^3 MPN/100 ml) and flood-high slack stage (1.2×10^3 MPN/100 ml). Inasmuch as there are no sanitary or combined sewage discharges between the Baker Street outfall and Baker's Beach (outside the Golden Gate Bridge), the factor-of-three difference in coliform MPN levels is attributable to the transport of coliforms from waste discharges located easterly of the Baker Street outfall.

The mean dry weather coliform MPN concentration at Station No. 25 was 3.5×10^2 MPN/100 ml, or about 80,000 times less than the mean dry weather flow level of 29×10^6 MPN/100 ml. The mean dry weather coliform MPN level at Station No. 25 (3.5×10^2 MPN/100 ml) is nearly 50 percent greater than the median level specified by the Regional Board for waters of Central San Francisco Bay (Reference VII-1). Consequently, the receiving waters at Outer Marina Beach are subject to water quality degradation which can be associated with adjacent and upstream discharges in the Bay system, and the mean coliform MPN level at Station No. 25 (mid-1966 to 1968) is significantly in excess of present receiving water requirements. Also, based on the dry weather coliform MPN data distribution in Figure VII-3, there is a two percent probability that the dry weather coliform MPN level at Station No. 25 will exceed the maximum level of 10,000/100 ml stated in the requirements (Reference VII-1).

The statistical analysis of the coliform data at Station No. 25 from mid-1966 to December 1968 also indicated that the mean wet weather coliform MPN levels at Station No. 25 decreased to mean dry weather levels in less than five dry-weather days after a rainy day. If the rate of decay of coliform MPN level to dry weather conditions is also representative of other parameters reflecting the beneficial uses of the receiving water (such as particulate floatables), then the number of days on which water quality will be impaired is a function of the discrete time intervals between storm patterns as well as of the time span between the initial and final rainfalls of the season. Based on the normal pattern of storms occurring annually in San Francisco, and using the above decay time for coliform MPN levels, it is estimated that receiving water coliform MPN levels at Outer Marina Beach exceed background dry weather levels about 20 percent of the time on an annual basis.

Another perspective for the coliform MPN problem in the receiving waters and shoreline at Outer Marina Beach can be seen from the comparison of coliform MPN distributions in waste discharges and receiving waters shown in Figure VII-1. The median of mean coliform MPN concentrations in dry weather flows from the five basins (Baker, Mariposa, Brotherhood, Selby, and Laguna) was 20×10^6 MPN/100 ml. The median of

mean coliform MPN concentrations in combined sewage flows from these basins was 6.2×10^6 MPN/100 ml, or 22 percent of the mean level for dry weather flows. The mean coliform MPN concentration for all wet weather samples at Station No. 25 is 19.5×10^2 MPN/100 ml, indicating that receiving water mean coliform MPN levels are about 3,000-fold less than the median coliform MPN levels in combined sewage flows.

The other area of concern with respect to existing receiving water quality is the nature and magnitude of floatable materials on water surface under wet and dry weather conditions. During wet weather conditions, the levels of floatable materials in receiving waters (average, 10.5 mg/sq m) are one to two orders of magnitude greater than detected under dry weather conditions (average, 0.55 mg/sq m). Moreover, the HEM fraction (relating to the quantities of grease and related products in the floatables) averaged two percent of the particulate floatables under wet weather conditions but less than 0.01 percent for most of the dry weather conditions. Consequently, upstream treated and untreated waste discharges have a significant impact on the floatables levels (and oil and grease fraction thereof) in the receiving waters of the Outer Marina Beach. The increased levels of floatables in the receiving waters under wet weather conditions are paralleled by a factor of two increase in the HEM content of the surface sand in the littoral zone.

IMPLICATIONS OF RECEIVING WATER EVALUATION

The foremost findings of the receiving water evaluation are that there exists positive interrelationships at Outer Marina Beach between or among:

(1) Receiving water and beach intertidal zone quality.

(2) Receiving water quality and tidal current stage, with a deterioration in water quality occurring on ebb and low slack tidal current stages.

(3) Receiving water quality and the climate, with a marked deterioration in water quality occurring during wet weather.

(4) The combined sewage overflows generated in the Baker Street drainage basin represented about three percent (on a five-year storm basis) of the total combined sewage overflows (on a flow rate basis) from all bypasses between Baker Street and Fourth Street South.

The implications of these findings with respect to current wastewater management planning in the City of San Francisco are two-fold:

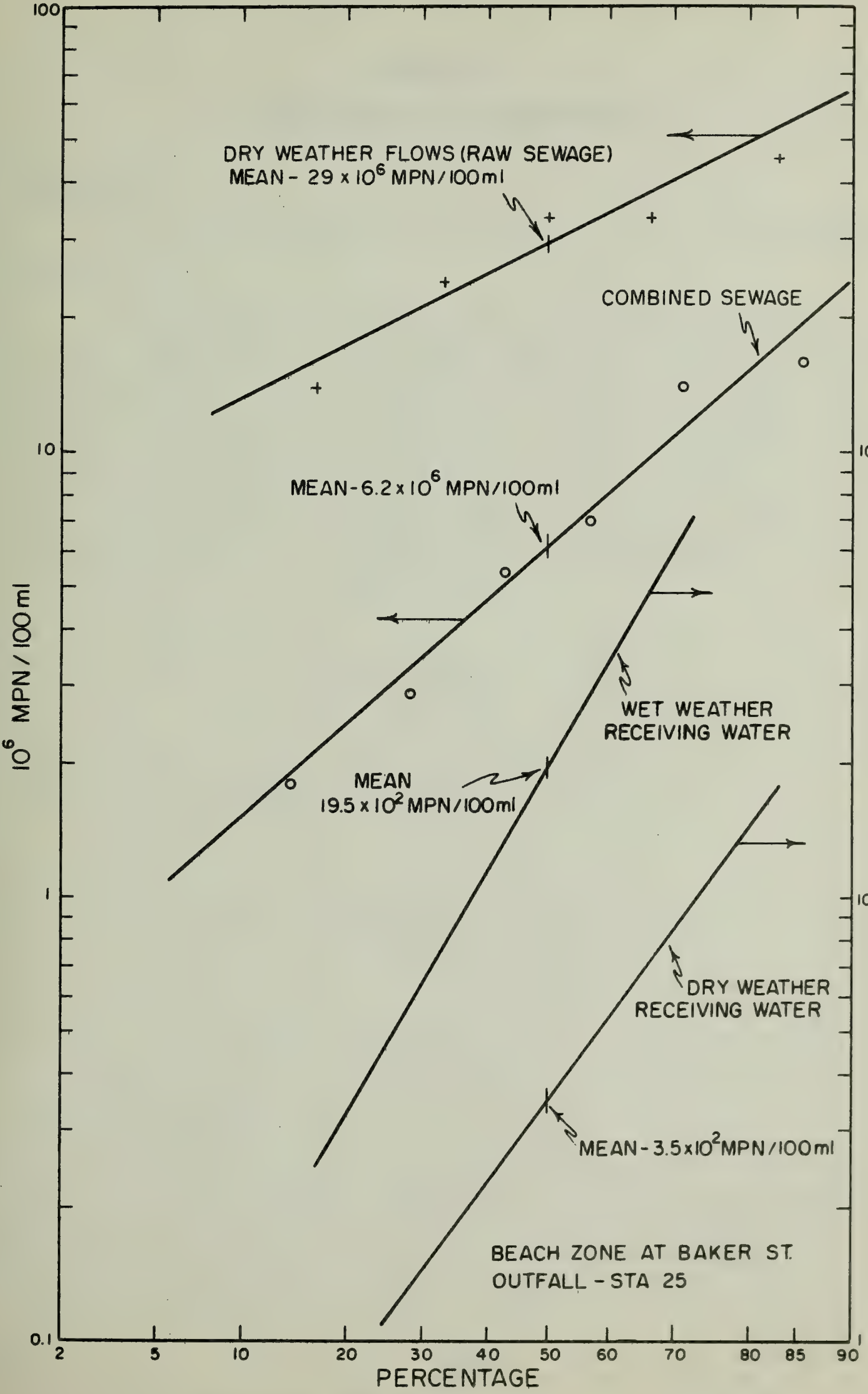
(1) It does not appear the demonstration dissolved air flotation facility at Outer Marina Beach will effect *per se* a major improvement in wet weather receiving water quality in that area.

(2) It does not appear that receiving water quality in the area west of Pier 45 can be improved by managing combined sewage overflows westerly of this point prior to and independent of effective control of overflows and treated effluent discharges easterly thereof. The findings of the present study offer strong preliminary evidence, requiring additional substantiation, that receiving water quality west of Pier 45 is dependent on the magnitude of waste discharges easterly of Pier 45.

CHAPTER VII - LIST OF REFERENCES

VII-1 *"Prescribing Requirements as to the Nature of Waste Discharge by the City and County of San Francisco From Wet Weather Diversion Structures in its North Point Sewerage Zone"*, Tentative Resolution, California Regional Water Quality Control Board, San Francisco Bay Region, dated 29 January 1970.

COMPARISON OF COLIFORM MPN LEVELS IN WASTE STREAMS AND RECEIVING WATERS



CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The following conclusions are based on the results and findings of this study:

(1) The multi-basin scope of the investigation was insufficient to permit development of storm runoff mass emission equations specific to the land use, land quality, miles of streets, etc. in each of the types of drainage basins studied in San Francisco. In lieu of specific equations, the following general storm runoff mass emission equations can be used to define wastewater loads (lb/acre) due to storm runoff and sewer system scour (developed for storms with average rainfall intensitites less than 0.20 in./hr):

(a) COD

$$M_{COD} = \frac{12\,\bar{i}}{0.01 + \bar{i}} \tag{VIII-1}$$

where: M = mass emission coefficient, lb/acre

$\bar{i}$ = mean runoff due to storm

(b) TSS

$$M_{TSS} = \frac{24\,\bar{i}}{0.001 + \bar{i}} \tag{VIII-2}$$

(c) TN

$$M_{TN} = \frac{0.60\,\bar{i}}{0.01 + \bar{i}} \tag{VIII-3}$$

(d) OPP

$$M_{OPP} = \frac{0.10\,\bar{i}}{0.01 + \bar{i}} \tag{VIII-4}$$

(e) HEM

$$M_{HEM} = \frac{2.1\ \bar{i}}{0.1 + \bar{i}} \qquad \text{(VIII-5)}$$

(f) Floatable Materials

$$M_{FM} = \frac{0.24\ \bar{i}}{0.01 + \bar{i}} \qquad \text{(VIII-6)}$$

(2) Per capita dry weather waste flow and mass emission coefficients and the above storm runoff mass emission equations can be used to estimate pollutant emissions from a drainage basin on a per storm, seasonal, or annual basis, given as input information the runoff coefficient, acreage, and population for the basin and historical rainfall data (defined by storm rainfall magnitude, basin runoff coefficient, and time intervals between storms).

(3) The median coliform MPN level in the dry weather sewages from Baker, Brotherhood, Mariposa, Selby, and Laguna basins was 20×10^6 MPN/100 ml. The median of mean coliform MPN concentrations in combined sewage flows from these basins was 6.2×10^6 MPN/100 ml, or 22 percent of the median level for dry weather flows. The median coliform MPN levels in storm water runoff from the Vicente Street basins were 7×10^5 and 1.6×10^5 MPN/100 ml, or five and one percent of the median level for dry weather flows, respectively. The mean coliform MPN concentrations for all wet weather receiving water samples at Station No. 25 (Outer Marina Beach) was 19.5×10^2 MPN/100 ml (mid-1966 to December 1968), or approximately 3,000-fold less than the median coliform MPN level in combined sewage flows. The mean dry weather receiving water coliform MPN level at Station No. 25 was 3.5×10^2 MPN/100 ml or about 80,000 times less than the median level in dry weather flows (29×10^6 MPN/100 ml) and 18 percent of the wet weather receiving water median coliform MPN concentration of 10.5×10^2 MPN/100 ml.

(4) The particle-size distributions of dry weather, combined sewage, and storm water runoff flows are such that approximately 90 percent of the total suspended solids in samples of these wastewaters can be removed by filtration through a membrane filter of 14 μ effective pore size.

(5) Storm runoff was found to contain (per unit of COD) about five times the TSS, three times the floatables, 8/10 the TN, 1/2 the HEM, and 4/10 the OPP found in dry weather flow.

(6) An example evaluation of dry weather and combined sewage flow quantities was made in the Baker Street drainage basin for a 2-1/2 month period (1 October to 15 December 1969), during which approximately 21 percent of the annual dry weather flow and 22 percent of the average precipitation occurred. Rainfall intensities of 0.02 in./hr occurred during approximately three percent of the 2-1/2 month period, and it was assumed that combined sewage overflows occurred during this fraction (three percent) of the time. The wastewater loads from this period were extrapolated to an annual basis (lb/acre-year); on this basis the following relationships were established in this example:

(a) Combined sewage overflows to receiving waters during wet weather account for the following percentages of the total annual wastewater emissions due to dry weather and storm runoff flows:

  (1) COD, eight percent.

  (2) TSS, 26 percent.

  (3) TN (total nitrogen), eight percent.

  (4) OPP (orthophosphate-phosphorus), five percent.

  (5) HEM (hexane extractable materials), six percent.

  (6) Floatable materials, 19 percent.

(b) The combined sewage overflows contain twice the OPP and HEM, 50 to 60 percent more COD and TN, 20 percent more floatables, and eight percent more TSS than would storm runoff for a separate storm sewage system for the same conditions considered in the example application.

(c) The pollutant emissions in untreated combined sewage overflows are similar in magnitude to storm runoff pollutant emissions and to the fraction of pollutants in

the dry weather flow not removed by secondary treatment. However, the nitrogen and phosphorus emissions from secondary effluents are significantly greater than emissions from combined sewage and storm water runoff flows on an annual basis.

(7) The foremost factor associated with the occurrence of peak concentrations of pollutants in combined sewage flows in the Baker, Laguna, and Brotherhood drainage basins was an increase in the rate of combined sewage flow following an increase in rainfall intensity; the antecedent dry period between rain storms was not observed to be a necessary condition for the occurrence of peak concentrations in the combined sewage flow.

(8) Based on seasonal and diurnal coliform MPN levels in the receiving waters at the shoreline of Outer Marina Beach as well as in the receiving water sampling grid (250 to 1,500 ft offshore), it can be concluded that:

(a) There is a factor-of-seven increase in coliform MPN levels between dry and wet weather conditions in both the shoreline (Station No. 25) and nearshore waters (250 to 1,500 ft offshore) at Outer Marina Beach.

(b) The median dry weather coliform MPN level of 350/100 ml in the shoreline zone exceeds by nearly 50 percent the present median level specified by the San Francisco Bay Regional Water Quality Control Board for waters of Central San Francisco Bay (January 1970).

(9) Based on a positive correlation between increased levels of HEM in the floatable particulates of the receiving waters (three to four orders of magnitude) and on sediments in the beach intertidal zone (two-fold) during wet weather, there is a definable interdependence between receiving water and beach intertidal zone quality in terms of materials of esthetic importance in the Outer Marina Beach receiving water area.

(10) For a five-year storm condition, the combined sewage overflow at Baker Street constitutes about three percent of the total combined.

sewage overflows from all bypasses between Baker Street and Fourth Street South in the northeast periphery of San Francisco. Based on that and on Conclusions 8 and 9, it is concluded that existing quality in the receiving waters and beach intertidal zone of Outer Marina Beach does not meet present levels of acceptability for the stated beneficial uses. Because of the implied impact of tributary wastewater discharges in the Bay system, it does not appear that the demonstration dissolved air flotation facilitiy now under construction at Outer Marina Beach (April 1970) will effect a major improvement in wet weather receiving water quality at Outer Marina Beach without the upgrading of treatment levels at other tributary wastewater discharges in the Bay system.

(11) The water quality characteristics manifesting the most significant changes in concentration between wet and dry weather in the shoreline and nearshore water of Outer Marina Beach are coliform MPN, floatable particulates, and HEM (hexane extractable materials).

(12) It does not appear that receiving water quality in the area west of Pier 45 can be improved by managing combined sewage overflows westerly of this pier prior to and independent of effective control of overflows and treated effluent discharges easterly thereof. The findings of this study offer strong preliminary evidence, requiring additional substantiation, that receiving water quality west of Pier 45 is dependent on the magnitude of waste discharges east of Pier 45.

RECOMMENDATIONS

The post-construction studies are planned as a direct sequel to this effort, and have the overall objectives of:

(1) Demonstrating the operational characteristics and performance capabilities of the dissolved air flotation facility at Outer Marina Beach.

(2) Evaluating changes in receiving water quality at Outer Marina Beach during operation of the treatment facility.

It is recommended that attention be focused, in the post-construction studies, on the performance capabilities of the dissolved air flotation facility of an influent-effluent basis rather than on the basis of identifying an improvement in receiving water quality. It is further recommended that the process evaluation as a minimum should consist of:

(1) Delineation of hydraulic flow-through patterns.

(2) Preliminary process evaluation based on operating runs of the facility using combined sewage, sanitary sewage, or sanitary sewage diluted with City water or Bay water. Each operating run should treat at least three flow-through volumes under steady flow conditions.

(3) Process evaluation should also be based on additional runs of the facility under the dynamic operating conditions imposed by rapidly changing flow rates and concentrations of pollutants in combined sewage flows.

It has been estimated (Chapter IV) that an average of 11 combined sewage overflows will occur in the Baker Street basin and be diverted to the treatment facility. It is unknown what fraction of the overflows consist of flow quantities which will equal or exceed the volume of tankage (420,000 gallons) in the demonstration facility; however, there is serious concern that inadequate volumes of wastewaters can be obtained for demonstration of the treatment facility. Therefore, it is recommended that modification be made to the diversion structure at Baker and Marina Streets to permit use of the storage capacity of the Baker Street combined sewer (approximately 1/4 million gallons) to increase volumes of wastewater available for experimentation under both dry and wet weather conditions.

The final recommendation of this study is that consideration be given to conducting receiving water studies in the immediate 200-ft diameter zone of receiving waters around the outfall for the demonstration treatment facility. Because of the significant impact of tributary wastewater discharges on receiving water quality at Outer Marina Beach, it is recommended that major emphasis be given to:

(1) Characterization of coliform MPN, floatable particulates, and turbidity in the surface water of the 200-ft diameter zone.

(2) Documentation of water current structure induced by tide and wind conditions in and adjacent to this zone.

(3) Quantification of the rate and extent of deposition of materials on Outer Marina Beach.

APPENDIX A

DRAINAGE BASIN AND RECEIVING ENVIRONMENT SAMPLING AND ANALYTICAL PROGRAMS

APPENDIX A

DRAINAGE BASIN AND RECEIVING ENVIRONMENT SAMPLING AND ANALYTICAL PROGRAMS

SCOPE

Three activity areas were considered in the drainage basin sampling program:

(1) Dry weather sampling at the Baker Street, Mariposa Street, and Brotherhood Way sampling stations.

(2) Combined sewage flow sampling at the Baker Street, Mariposa Street, and Brotherhood Way sampling stations.

(3) Storm runoff at the Vicente Street (Areas 1 and 2) drainage basin.

Dry weather monitoring was conducted at the Baker, Mariposa, and Brotherhood basins to provide data for calculation of mass contributions of dry weather flow to combined sewage flows, and to investigate the effects of dry weather sewage on combined sewage quality. Combined sewage flow monitoring was conducted at these same basins in order to provide quantitative descriptions of the mass emission of pollutants and to characterize the time-variant concentration profiles of pollutants over the duration of storm runoff. Storm runoff monitoring at the Vicente basin was carried out to ascertain the time-concentration profiles and mass emissions of pollutants in storm runoff flows having no sanitary sewage component.

The schedule for dry and wet weather monitoring at Baker, Mariposa, and Brotherhood basins and wet weather monitoring in the Vicente basin is shown in Table A-1. Included in Table A-1 is the schedule of dry and wet weather monitoring for the Selby and Laguna basins done in the 1966-1967 study (Reference A-1). A total of 11 wet weather and three dry weather monitorings were conducted in this study, and a total of nine wet weather and 14 dry weather monitorings were done in the 1966-1967 study. The combined results of this and the previous study provide data for characterization of combined or storm sewage flow from a total

TABLE A-1

SCHEDULE OF MONITORING ACTIVITY

Drainage Basin	Monitoring Activity	Date
Baker Street	CSF	4- 5 April 1969
		15 October 1969
		5 November 1969
	DWF	19-20 May 1969
Mariposa Street	CSF	27-28 February 1969
		20 March 1969
		2 April 1969
	DWF	2- 3 June 1969
Brotherhood Way	CSF	14 January 1970
		15 January 1970
		23 January 1970
	DWF	16-17 January 1970
Vicente Street (Areas 1 and 2)	SRO	16 February 1970
Selby Street	CSF	6 November 1966
		14-15 November 1966
		20 January 1967
		23 January 1967
		24 February 1967
		10 March 1967
		15 March 1967
	DWF	6 September 1966
		8- 9 September 1966
		11-12 September 1966
		17-18 September 1966
		21 September 1966
		23-24 September 1966
		26-27 September 1966
		2- 3 October 1966

TABLE A-1 (Cont'd)

SCHEDULE OF MONITORING ACTIVITY

Drainage Basin	Monitoring Activity	Date
Laguna Street	CSO	10 March 1967
		15 March 1967
	DWF	6 September 1966
		8- 9 September 1966
		11-12 September 1966
		17-18 September 1966
		20-21 September 1966
		23-24 September 1966

NOTE: CSO - Combined sewage flow;
DWF - Dry weather flow;
SRO - Storm runoff overflows.

of six different drainage basins in San Francisco.

FLOW MEASUREMENT

Flow measurement for all monitoring events in the present study was carried out using a dye-dilution technique. Concentrated dye solutions (Rhodamine WT) were injected into the sewage flow at manholes 500 to 700 feet upstream from the sampling points.

Dye solutions were injected at the locations indicated in Figures IV-2 through IV-6 for each basin. Samples were taken at the downstream station for both flow measurement and water quality evaluation at hourly intervals for dry weather monitoring. During wet weather monitoring, samples were taken each 10 minutes in the first hour after runoff or diversion commenced, every 20 minutes in the second hour, half-hourly in the third to sixth hours, and hourly thereafter. All sampling stations were located in sections of the sewer system where homogeneous samples could be obtained.

Dye injection was done with Sigmamotor No. TM-35-100 Kinetic Clamp Pumps having a range of delivery rates from 12 to 500 ml/min. The flow rate of the pump was calibrated with a stopwatch and graduate cylinder on an hourly basis over the duration of a monitoring event. The pumps were powered by portable 110-volt gasoline-powered generators, and the generator-pump sets proved to be a highly durable and versatile system for this purpose.

The dye-dilution technique was selected because it offered the following advantages over pressure-differential and stress-strain systems for velocity measurement:

(1) Only small quantities of dye solution were needed because dye concentrations of <20 μg/l could be detected with fluorometric techniques.

(2) Analytical interferences associated with solid and organic matter in waste streams (due to sorption, reduction of light transmissibility, and decay) were found by testing to have minimal importance with the dry and wet weather streams sampled.

(3) Tests showed that flow turbulence in the 500- to 700-ft reach of sewer provided complete mixing of the injected dye with the sewage flow at the selected points of sampling.

The portable generator-pump dye injection system discussed above was operated manually in conjunction with sampling at the Mariposa, Brotherhood, and Vicente basins. At the Baker Street basin, a generator-pump system was housed in an enclosed shed and was connected by a buried electrical cable to the semi-automatic sampling station used at that basin and discussed below. The generator-pump system at Baker Street was activated by controls located in the sampling station.

SAMPLING

Previous studies in San Francisco (Reference A-1) led to the conclusion that a major portion of the waste mass emission takes place in the first few hours after runoff commences, and that significant variation of concentrations of waste constituents is to be expected in this interval. Thus, it was mandatory that samples be taken at frequent intervals immediately after the onset of runoff. The times of concentrations at the sampling sites for the four basins considered (Baker, Mariposa, Brotherhood, and Vicente basins) were estimated to be less than 15 minutes, thus, necessitating the use of either standby personnel or semi-automatic sampling stations activated at the onset of runoff or diversion, in order to obtain samples just as the event started. Both approaches (standby personnel and automatic station) were used in the monitoring program. Standby personnel were used in monitoring combined sewage flows at the Mariposa, Brotherhood, and Vicente basins. A semi-automatic dye-injection-sampling station was developed and constructed for all combined sewage monitoring at Baker Street.

Standby personnel at the Mariposa, Brotherhood, and Vicente basins used both the portable generator-dye injection set discussed above and a portable sewage sampling pump and second generator set. The pump units were self-priming centrifugal pumps with a one-inch sphere-handling capacity and a static prime of 25 feet. The pump intake and discharge lines consisted of 1-1/2-inch diameter heavy rubber hoses;

the pump intake line was fitted with a foot valve and the intake was positioned to lay on the bottom of the sewer. Samples of combined and storm sewage flows were taken at the intervals discussed previously, *i.e.*, each 10 minutes during the first hour after runoff or diversion commenced, every 20 minutes in the second hour, half-hourly in the third to sixth hours, and hourly thereafter.

Dry weather monitoring at the Brotherhood, Mariposa, and Vicente basins was carried out on a scheduled 24-hr basis using the above portable equipment inventory and hourly sampling intervals.

The operational objectives for the semi-automatic sampling station at Baker Street was to develop a system which could sample at 10-minute intervals for an initial period of 80 minutes, commencing at the start of runoff, during which interval field personnel would have time to arrive at the site and take over manual sampling. The sampling system is shown schematically in Figure A-1 and has the following key components:

(1) Self-priming pump (described above).

(2) Flow director, which is activated by solenoid and held in the sampling position for 10 seconds every 10 minutes.

(3) Sample distributor, which is rotated by a small motor at one revolution per 80 minutes and which distributes sewage for 10 seconds at 10-minute intervals to each of a series of eight 5-gallon wide-mouth sample containers.

The pump, the timer activating the solenoid on the flow distributor, the dye-injection system, and the sample distributor are activated by a pressure switch as depth of flow increases in the sewer, and are operated continually until shut off manually. With the semi-automatic sampling it was possible to continue sampling at 10-minute intervals after the initial 80-minute interval by manually replacing the filled 5-gallon containers with empty containers; it is also possible to sample the sewage stream at any time for purposes of measuring flow rate (dye concentration). The entire sampling system shown in Figure A-1 was enclosed in a 9-ft by 9-ft shed.

Wet weather sampling at Baker Street was conducted using the semi-automatic sampling system operated as described above; dry weather monitoring was done using the dye-injection system and sampling pump on a manual control basis. The dry and wet weather sampling intervals were the same respectively as reported above for Brotherhood, Mariposa, and Vicente basin monitoring.

SAMPLE MANAGEMENT

Samples were taken by filling two containers directly from the pump discharge hose on each occasion. One 5-gallon sample was taken for general chemical analysis and floatables and a one liter sample was taken for the HEM (hexane extractable materials, or grease) analysis. Sample temperatures were measured immediately. Wet weather samples were returned to the laboratory immediately after the sample program was terminated, such that the longest delay between time of sampling and delivery to the laboratory for analyses was 10 hours. Dry weather samples were delivered to the laboratory at 8-hour intervals (three times) during each 24-hour monitoring event.

Sample analysis commenced immediately upon delivery of the samples to the laboratory. When storage was required the samples were refrigerated at 4°C and the storage was not allowed to exceed 48 hours.

ANALYTICAL METHODOLOGY

A schedule of analytical methods used with dry weather, combined, and storm sewage samples is given in Table A-2. Source references for the analytical procedures are as follows:

(1) COD, BOD, total and ammonia nitrogen, alkalinity, electrical conductivity, toxicity (96-hr TL_m or 96-hr percent survival): per *Standard Methods for Evaluation of Water and Wastewater* (12th edition) (Reference A-2).

(2) TSS and VSS (glass filter) and orthophosphate-phosphorus (colorimetric): SERL Analytical Methods (Reference A-3).

TABLE A-2

SCHEDULE OF ANALYTICAL METHODS
DRY WEATHER, COMBINED, AND STORM SEWAGE SAMPLES

Analysis	Schedule
COD	All samples
BOD	3 to 5 samples/event
TSS (total suspended solids)	All samples
VSS (volatile suspended solids)	All samples
HEM (hexane extractible materials)	All samples
Floatable materials	All samples
Total Nitrogen	All samples
Ammonia Nitrogen	All samples
Orthophosphate-phosphorus	All samples
Alkalinity	All samples
Electrical Conductivity	All samples
Toxicity, 96-hr TL_m Toxicity, 96-hr % survival	2 to 3 samples per one wet weather event per basin
Particle size distribution	3 to 5 samples per event
Total and Fecal Coliforms	All samples

(3) Floatable materials (gravimetric) and HEM (liquid-liquid extraction): Engineering-Science, Inc. (Reference A-4).

The particle-size distribution was determined by sequential filtration of samples through glass filters with nominal pore sizes of 74 μ, 14 μ, 5 μ, and 0.45 μ. The solids accumulated on each filter were measured by the above SERL technique for TSS, and the results reported as percent TSS accumulated on a filter of given nominal pore size.

RECEIVING WATER AND BEACH INTERTIDAL ZONE SAMPLING PROGRAM

Scope

The receiving water program was planned to provide reference data in the receiving waters and beach intertidal zone contiguous to Baker Street which is needed for evaluation of the effectiveness of the dissolved air flotation unit for maintaining and enhancing environmental quality. The demonstration of the treatment units for improving environmental quality will require identification of the background characteristics of receiving waters in the estuary, the quality of which is affected not only by other waste discharges, but also by storm water runoff and natural drainage into the estuary system.

Criteria for Sampling Program

The design of a suitable sampling program required a basic understanding of the factors affecting the background quality in the receiving environment for the new facility. Two factors of primary concern were:

(1) Efficiency of treatment and disinfection at adjacent treatment plant discharging to the estuary.

(2) Effect of tides on circulation within the estuary and the exchange of estuarine with marine waters.

Because of these factors, criteria were needed to design a sampling program in which background characteristics of the receiving environment could be determined with a minimum of interference from external phenomena.

In order to establish these criteria it was necesary to examine the base of existing information to identify what the impact of the above are. The only extensive information base available for accomplishing this goal was resident in the shoreline coliform monitoring program of the City of San Francisco. The coliform data were selected not only because of their completeness, but also because of the importance of the coliform parameter as a measure for acceptable water quality.

Data Base

The City of San Francisco has conducted an on-going coliform monitoring program for many years. Twenty-six sampling stations are located in the nearshore waters from the Yacht Harbor to the Central Basin (Figure VI-11). Most of these are monitored four times weekly, Monday and Wednesday morning, and Tuesday and Thursday afternoon. These data are available in the convenient form of weekly summaries, presenting daily MPN determinations at all 26 stations, time of sampling, and amount of daily rainfall observed during the interval of record.

As a basis for establishing criteria for the sampling program, these data were analyzed to determine the statistical significance of differences in coliform MPN concentrations between observations made at (1) different stages during rainy days in wet months, and (2) during dry days in wet months and one dry month (August). The analysis consisted of determination of the mean, standard deviation, and standard error of means among the sets of data. The significance of the differences among the sets of data was determined by the 180° overlap test with the standard error of mean (Reference A-5) which is a much more severe test than the student "t" test.

All coliform MPN data available from mid-1966 to December 1968 were used in the data analysis. Data developed prior to mid-1966 were not used because chlorination procedures had been initiated at the treatment facility of the East Bay Municipal Utility District in early 1966, resulting in a marked reduction of coliform MPN levels in Central San Francisco Bay at that time.

Data from the following stations were selected for analysis:

SF Code	Description
23	At Marina Green, foot of Webster Street.
24	Marina Green, pump station outfall.
25	Outer Marina Beach at Baker Street outfall, west of St. Francis Yacht Club.
26	Beach in yacht harbor, between St. Francis Yacht Club and Marina Blvd.

A rainy day during wet months was defined as the day of, or following, a rainfall greater than 0.02 inches. This reference was selected because the sewerage system in San Francisco is designed to bypass combined sewage flows when the rainfall is in excess of 0.02 inch per hour. In accepting this criterion it was recognized that a total daily rainfall of 0.02 inch does not necessarily imply that a rainfall of 0.02 in./hr intensity has occurred; however, the criterion did eliminate data for those days on which overflows could not have occurred.

The four tidal current stages into which the data were sorted were:

(1)	Low Slack:	between the second and third hours after maximum ebb current.
(2)	Flood:	between the second and third hours before maximum flood current.
(3)	High Slack:	between the maximum flood current and the second hour after maximum flood current.
(4)	Ebb:	between the third hour after maximum flood current and the first hour after maximum ebb current.

The available data also presented an opportunity for determining the fluctuation of coliform MPN levels in the receiving waters after cessation of overflows. Fluctuations in coliform levels for this situation were ascertained by:

(1) Determination of mean coliform MPN levels for each tidal current stage and for the second, third, and fifth days after "rainy days" as defined above.

(2) Comparison of these levels for mean coliform MPN levels at each tidal current stage on rainy days and for dry weather conditions.

Effect of Tidal Current Stage and Weather Conditions

A computer sorting technique was used to place the data base in a format suitable for evaluating the effects of tidal current stage and weather conditions on coliform MPN levels at the selected stations. The results of the computer analysis are presented in Table A-3 and the basic data used in the analyses have been presented in the February 1969 Progress Report (Reference A-6).

The mean coliform MPN concentrations (averaged for all current stages) for the observation period varied from 0.62 log unit (Station 26) to 0.94 log unit (Station 24) greater during wet weather conditions than the respective mean concentrations during dry weather. That is, coliform MPN concentrations at these stations were from four to nine times greater during wet weather than during dry weather. At Outer Marina Beach (Station 25), coliform MPN concentrations in wet weather were six times greater (0.75 log unit) than in dry weather. Thus, a significant increase in coliform MPN concentrations at the Baker Street site and elsewhere in the vicinity of that site can be expected with the onset of wet weather conditions.

An analysis of the statistical characteristics of the coliform MPN data observed at Outer Marina Beach during the four tidal current stages on rainy days is presented in Table A-4. The data distributions for each tidal current stage were compared with the 180° overlap test, whereby the statistical significance of the distributions is assessed as a function of the degree of overlap of the standard error of means of the distributions (Reference A-5). The results of the analysis show that no statistically significant difference exists between the distributions of coliform MPN observations at ebb and low slack, or between distributions at high slack and flood stages. However, the distribution of coliform MPN concentrations at ebb and at low slack were found to be significantly different from the distributions at flood and at high slack stages at a 68 percent confidence level.

TABLE A-3

COLIFORM MPN DATA SUMMARY

Weather and Tidal Currents	Station, mean log MPN/100 ml ($\bar{X}$), Standard Deviation (S.D.), & No. Observations (N.)											
	Marina Green @ Webster St. (#23)			Marina Green, Pump Station Outfall (#24)			Outer Marina Beach @ Baker St. Outfall (#25)			Beach in Yacht Harbor (#26)		
	$\bar{X}$	S.D.	N.	$\bar{X}$	S.D.	N.	$\bar{X}$	S.D.	N.	$\bar{X}$	S.D.	N.
Dry days, all currents	2.32	.539	151	2.43	.608	150	2.54	.700	154	2.23	.632	83
Rainy days, all currents	2.98	.693	93	3.37	1.100	92	3.29	.894	98	2.85	.794	56
Dry days, low slack	2.34	.624	27	2.35	.490	27	2.91	.800	27	2.19	.539	16
Dry days, flood	2.42	.566	34	2.46	.632	34	2.47	.648	35	2.17	.557	18
Dry days, high slack	2.24	.520	21	2.42	.374	21	2.37	.510	21	2.04	.424	111
Dry days, ebb	2.28	.490	69	2.45	.693	68	2.49	.700	71	2.33	.742	38
Rainy days, low slack	3.02	.800	18	3.53	1.414	18	3.55	1.039	18	2.64	.728	10
Rainy days, flood	2.79	.539	26	3.21	.964	25	3.10	.735	29	2.84	.529	17
Rainy days, high slack	3.18	.883	10	3.96	1.425	10	3.07	.812	11	3.19	.854	8
Rainy days, ebb	3.04	.686	39	3.25	.894	39	3.36	.938	40	2.84	.970	21

NOTES: (1) All data from sampling program between 1 July 1966 and 30 December 1968.

(2) Dry days: days of August 1966, 1967, and 1968 & dry days during wet months, except as in Item 3.

(3) Rainy days: days of moths in 1966 (last half), 1967, and 1968 where rainfall exceeded 0.02 inch, and days subsequent to days when rainfall exceeded 0.02 inch.

(4) Low slack: between 2nd and 3rd hour after maximum ebb current.
Flood: between 2nd and 3rd hour before maximum flood current.
High slack: between maximum flood current and 2nd hour after maximum flood current.
Ebb: between 3rd hour after maximum flood current and 1st hour after maximum ebb current.

TABLE A-4

EFFECT OF TIDAL CURRENT STAGE ON COLIFORM MPN: OUTER MARINA BEACH AT BAKER STREET OUTFALL (STA. 25)

Tidal Current	$\overline{X}$ $\left(\frac{\log \text{MPN}}{100 \text{ ml}}\right)$	90%-ile Range $\left(\frac{\log \text{MPN}}{100 \text{ ml}}\right)$	SD $\left(\frac{\log \text{MPN}}{100 \text{ ml}}\right)$	N	SE mean $\left(\frac{\log \text{MPN}}{100 \text{ ml}}\right)$	Significance @ 180° Overlap Test		
						Tide Stage	@ 1 SE	@ 2 SE
Low Slack	3.55	2.50 - 4.62	1.039	18	0.245	Flood	Yes	No
						High Sl	Yes	No
						Ebb	No	No
Flood	3.10	2.52 - 3.67	.735	29	0.137	High Sl	No	No
						Ebb	Yes	Yes
High Slack	3.07	2.39 - 3.75	.812	11	0.245	Ebb	No	No
Ebb	3.36	2.34 - 4.25	.938	40	0.148			

Notes: (1) $SE_{mean} = \frac{SD}{\sqrt{N}}$ where: SE_{mean} = standard error of mean; SD = standard deviation; no observations.

(2) Significance at 1 SE, 68% confidence; @ 2 SE, 95% confidence.

(3) 180° overlap test (Reference A-5).

The magnitude of the differences between ebb-low slack stages and flood-high slack stages during wet weather is evidenced by the mean MPN concentrations at each stage, *i.e.*:

Flood: 1,260/100 ml
High Slack: 1,180/100 ml
Ebb: 3,360/100 ml
Low Slack: 3,550/100 ml

Thus, mean coliform MPN concentrations at low slack and ebb are three times greater than those during high slack and flood stages for wet weather conditions.

There are several explanations for these differences:

(1) Significant quantities of ocean water are transported into the Bay system on flood tide. There are no sanitary sewage discharges or combined sewer overflows between the Baker Street overflow and Baker's Beach overflow, the latter located at a point several miles southwesterly and outside of the Golden Gate.

(2) The ebb tide transports significant quantities of diluted treatment plant effluents and combined sewer overflows from the southern estuary of the Bay past the northeasterly shore of San Francisco to the ocean.

This preliminary analysis identified that the tidal current stage has a significant effect on coliform MPN concentrations. It follows that coliform MPN concentrations determined in the pre-evaluation studies should be compared with similar data developed in the post-evaluation study on the basis of tidal current stage and weather conditions at the time of sampling.

Fluctuation in Coliform MPN Levels After Cessation of Wet Weather

The fluctuation of coliform MPN levels upon cessation of rainfall was evaluated for Stations 24 (Marina Pump Station outfall) and 25 (Outer Marina Beach) by the procedure described previously. The

results of the analysis are presented in Figure A-2 for all four tidal current stages. The mean coliform MPN at Station 24 decreased from levels at or greater than 3.4 log units (2,500 to 10,000 MPN/100 ml) on the rainy days to the background dry weather average of 2.43 log units (270 MPN/100 ml) within five days. The rates of decrease in coliform MPN varied from 0.18 log unit/day at ebb to 0.37 log unit/day at low slack.

The mean coliform MPN levels at Station 25 (Outer Marina Beach) decreased from in excess of 3.9 log units (1,200 to 3,200 MPN/100 ml) on the rainy days to levels below the background dry weather average of 2.54 log units (320 MPN/100 ml) within five days. The rates of decrease in coliform MPN from 0.18 log unit/day at ebb to 0.28 log unit/day at flood.

The foregoing evaluation, while based on data assembled within a limited (1-1/2 year) time frame, permits the following observations to be made with respect to Stations 24 and 25:

(1) Coliform MPN levels were found to decrease from mean wet weather levels (on rainy days as defined herein) to mean dry weather levels at all tidal current stages within five dry weather days after the rainy day.

(2) The minimum average rates of decrease in coliform MPN levels at both stations (0.18 log unit/day) occurred during ebb tidal current stage.

(3) The maximum average rate of decrease in coliform MPN levels occurred during low slack at Station 24 and during flood at Station 25.

The above observations have substantial implication in the evaluation of the impact of wet weather discharges on receiving water quality. The information derived in the foregoing analysis has been used elsewhere in this report (Chapter VII) to establish a temporal context for evaluation of the impact of wet weather discharges on receiving water quality.

Criteria for Sampling Program

The most important factor of concern relative to sampling program

design is that significant differences in mean coliform MPN concentrations were observed at the Baker Street site between low slack-ebb and high slack-flood tidal current stages. It was likely that the proximity of the Baker Street outfall to the coliform sampling station (approximately 60 ft) had a positive impact on the mean coliform MPN concentration at that sampling station throughout all tidal current stages; and that the background effects of adjacent combined sewer overflows were also evidenced during low slack and ebb stages.

On the basis of these observations the background sampling was scheduled during high slack and flood stages, and several stations were selected both westerly and easterly of the existing outfall site to maximize the possibility of detecting the impact of discharges directly from the Baker Street outfall on the receiving environment.

Sampling Program

The sampling program consisted of three coordinated efforts (two wet weather and one dry weather) for sampling the receiving surface waters and sediments and the intertidal beach sediments of Outer Marina Beach. Twelve receiving water stations were selected for sampling as described in Table A-5 and shown in Figure A-3. Seven stations (Nos. 1 through 7) are located approximately 250 feet offshore and Station 1 is approximately 250 feet offshore and on the existing alignment of the Baker Street outfall.

A second line of stations (Nos. 9 through 11) are positioned approximately 1,500 feet offshore. A single station (No. 8) is positioned between these two lines of stations approximately 600 feet offshore on the existing outfall alignment. Station No. 12 (south of Alcatraz Island) is the same as Station CB-5 of the University of California study (Reference A-7, 1964) and was sampled to develop data permitting a comparison between present and recent historical water quality in the esturary.

Surface water samples were collected from a depth of three feet at all twelve stations and analyzed for temperature, phytoplankton, chlorosity, and coliform (total and fecal) organisms. Water transparency readings were also made at these locations.

TABLE A-5

DESCRIPTION OF SAMPLING STATIONS
RECEIVING WATER STUDIES

Station	Type	Location	Notes
1	ABB	Existing outfall alignment, ~ 250 ft offshore	
2	ABB	3,000 ft W/O ex. alignment, ~ 250 ft offshore	
3	B	1,500 ft W/O ex. alignment, ~ 250 ft offshore	
4	ABB	600 ft W/O ex. alignment, ~ 250 ft offshore	At proposed discharge
5	ABB	600 ft E/O ex. alignment, ~ 250 ft offshore	
6	B	1,500 ft E/O ex. alignment, ~ 250 ft offshore	
7	B	3,000 ft E/O ex. alignment, ~ 750 ft offshore	
8	B	Existing outfall alignment, ~ 600 ft offshore	
9	B	1,500 ft W/O ex. alignemnt, ~ 1,500 ft offshore	
10	B	Existing outfall alignment, ~ 1,500 ft offshore	
11	B	1,500 ft E/O ex. alignment, ~ 1,500 ft offshore	
12	ABB	~ 1,650 ft S/O Alcatraz I. lighthouse	Station CB-5, UC Study (Reference IV-7)

NOTE: ABB - Aquatic, benthic, and bacteriological sampling

B - Bacteriological sampling

Trawl net sampling of floatable materials was conducted between two sets of stations, Stations 1 and 2 westerly, and Stations 1 and 7 easterly, of the existing alignment. At five of the receiving water stations (Nos. 1, 2, 4, 5, and 12) sediments were collected and analyzed for benthic animals, particle-size distributions, hexane extractable materials (HEM), total nitrogen, and total sulfides.

The six intertidal beach stations were located along the Outer Marina Beach-Crissy Air Field Beach sector as shown in Figure A-9. Station 2 is located below the Baker Street discharge point. Stations 1 and 3 were 10 ft to the east and 120 ft to the west, respectively. of Station 2. Stations 4, 5, and 6 were 1,100, 4,600, and 6,000 ft west of Station 2. Sediment samples were analyzed for particle-size distribution and HEM.

Methods of Sample Collection and Analyses

The analytical program for receiving water and beach intertidal zone studies is shown in Table A-6. A boat was used for sampling of the offshore stations. Surface waters were sampled with a bucket sampler. Temperature measurements of the water were made on-deck. Transparency determinations were conducted by lowering a secchi disc to the limit of visibility. Water samples for coliform analyses were collected in sterilized bottles and analyzed in accordance with the multiple tube fermentation method (Reference A-2). A portion of the sample was set aside for chlorosity analysis (Reference A-1). A one-liter aliquot was withdrawn from the sample volume and preserved with a dilute solution of rose bengal dye and formalin solution for phytoplankton analysis. These organisms were counted and identified under a high-power microscope.

The floatables sampler (Appendix H) was utilized to obtain samples for particulate and film (HEM) analysis. Particulate materials were categorized and the amounts in the various categories determined. The HEM analysis (Reference A-4) was performed on the particulate floatable materials.

The sediments were sampled with a Peterson dredge. A portion of the

TABLE A-6

ANALYTICAL PROGRAM FOR RECEIVING WATER AND BEACH INTERTIDAL ZONE STUDIES

Type of Sample	Analysis	Method	Reference
Benthic	Total nitrogen	Standard Methods	A-2, A-7
	Total sulfide	Titration	A-7
	Particle size distribution	Hydrometer	A-7
	Hexane extractible material	Liquid-liquid extraction	A-7
	Benthic animals: species distribution and number	Standard counting	A-2
Water Column	Coliforms - total	44-45^{o}C confirmed	A-2
	Coliforms - fecal	MPN	A-2
	Floatables	Gravimetric	A-3, A-4
	Chlorosity		A-7
	Phytoplankton: species distribution and number	Standard counting	A-2
Beach Intertidal Zone	Particle size distribution	Standard sieves	
	Hexane Extractible material	Liquid-liquid extraction	A-7
	Floatables	Gravimetric	A-3

sediment was preserved with zinc acetate for total sulfide analysis (Reference A-2). A second portion was preserved with dilute acid solution for the total nitrogen analysis (Reference A-2). A third portion of the sediment sample was bottled for particle-size distribution analysis (Reference A-3) and determination of HEM (Reference A-4). A second dredge sample was collected and preserved with rose bengal dye-formalin solution for benthic animal characterization.

The beach sediments from the intertidal zone were collected with a sled sampler device (Reference A-8). The particle-size and HEM analyses were performed on the collected samples as described in References A-2 and A-3.

APPENDIX A - LIST OF REFERENCES

A-1 *"Characterization and Treatment of Combined Sewer Overflows"*, report to City and County of San Francisco, by Engineering-Science, Inc., November, 1967.

A-2 *"Standard Method for Analysis of Water and Wastewater"*, American Public Health Association (12th Edition), 1965.

A-3 *"Analytical Methods"*, Sanitary Engineering Research Laboratory, University of California, March 1966.

A-4 *"Determination and Removal of Floatable Material from Wastewater"*, report by Engineering-Science, Inc. to United States Department of Health, Education, and Welfare, Public Health Service, 1965.

A-5 Velz, C.J., *"Graphical Approach to Statistics"*, Water and Sewage Works.

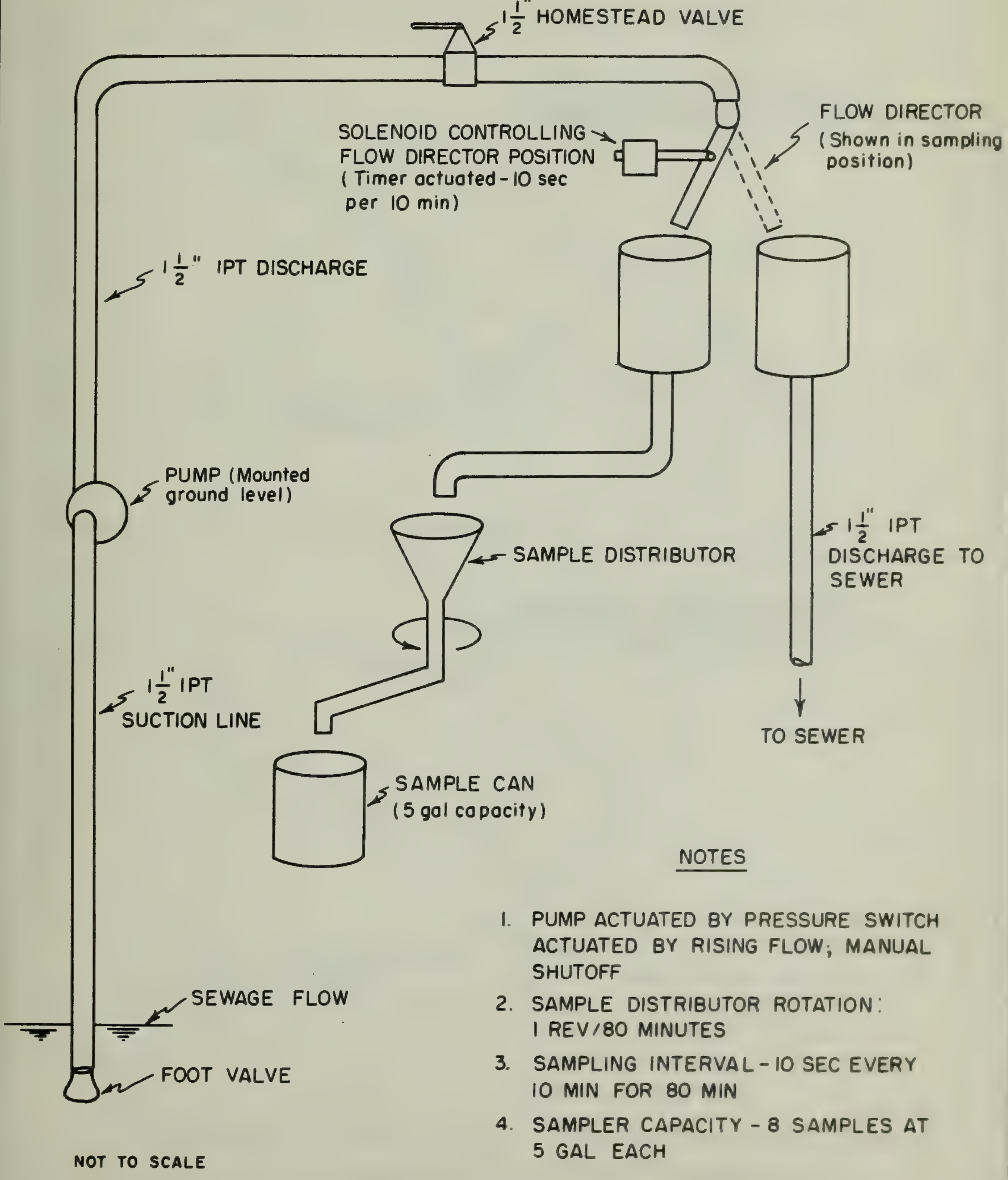
A-6 Progress Report, submitted to Department of Public Works, City and County of San Francisco by Engineering-Science, Inc., February 1969.

A-7 Final Report - A Comprehensive Study of San Francisco Bay, Volume I, *"Physical, Chemical, and Microbiological Sampling and Analytical Methods"*, SERL Report No. 65-07, University of California, Berkeley, 1965.

A-8 *"Analytical Characteristics of Oil Substances Found on Southern California Beaches*, report by Engineering-Science, Inc. for Western Oil and Gas Association, July 1960.

FIGURE A - I

SCHEMATIC OF SEMI-AUTOMATIC SAMPLING STATION
BAKER STREET DRAINAGE BASIN

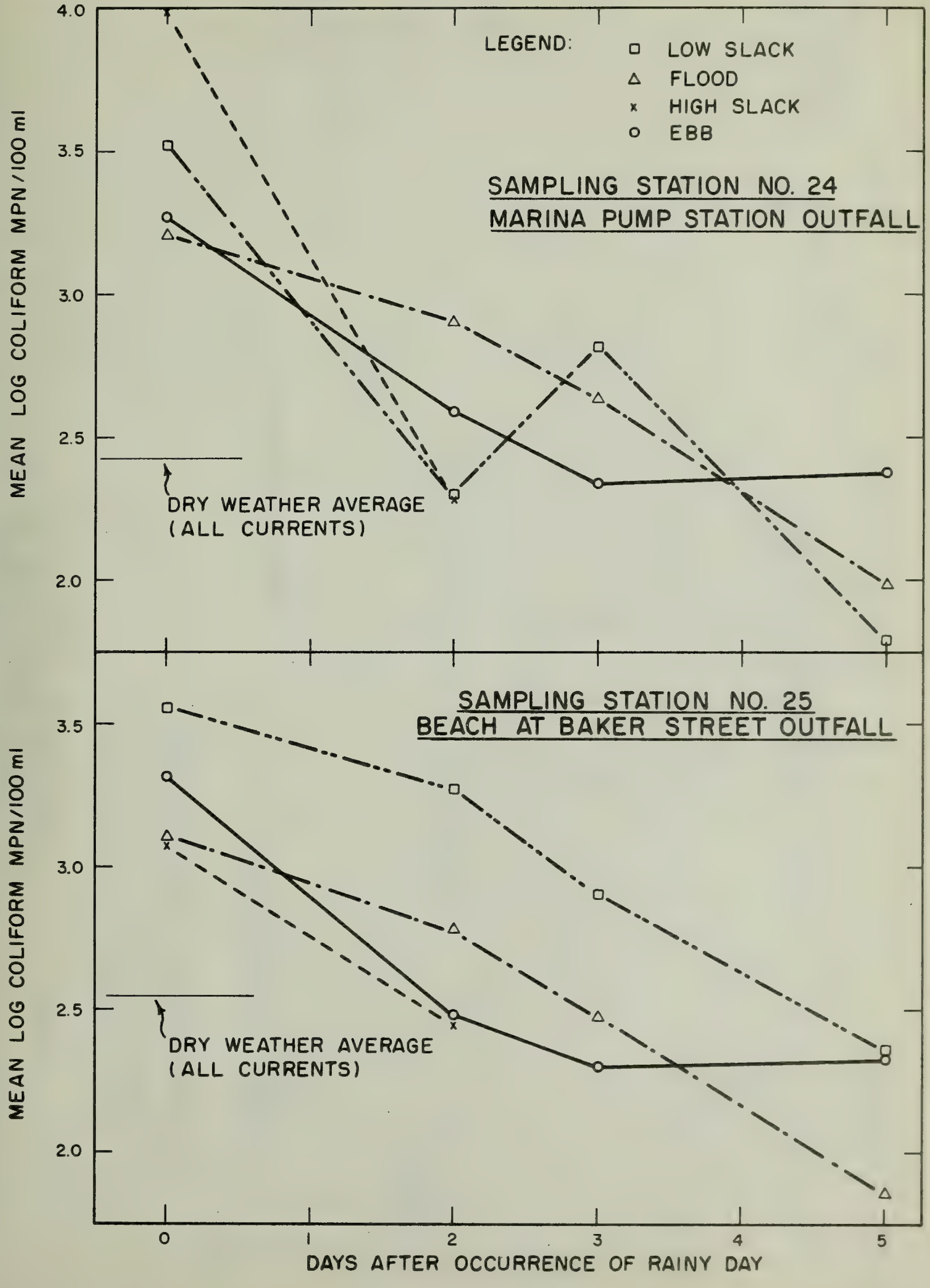

$1\frac{1}{2}$" HOMESTEAD VALVE
SOLENOID CONTROLLING FLOW DIRECTOR POSITION (Timer actuated - 10 sec per 10 min)
FLOW DIRECTOR (Shown in sampling position)
$1\frac{1}{2}$" IPT DISCHARGE
PUMP (Mounted ground level)
SAMPLE DISTRIBUTOR
$1\frac{1}{2}$" IPT DISCHARGE TO SEWER
$1\frac{1}{2}$" IPT SUCTION LINE
TO SEWER
SAMPLE CAN (5 gal capacity)
SEWAGE FLOW
FOOT VALVE
NOT TO SCALE

NOTES

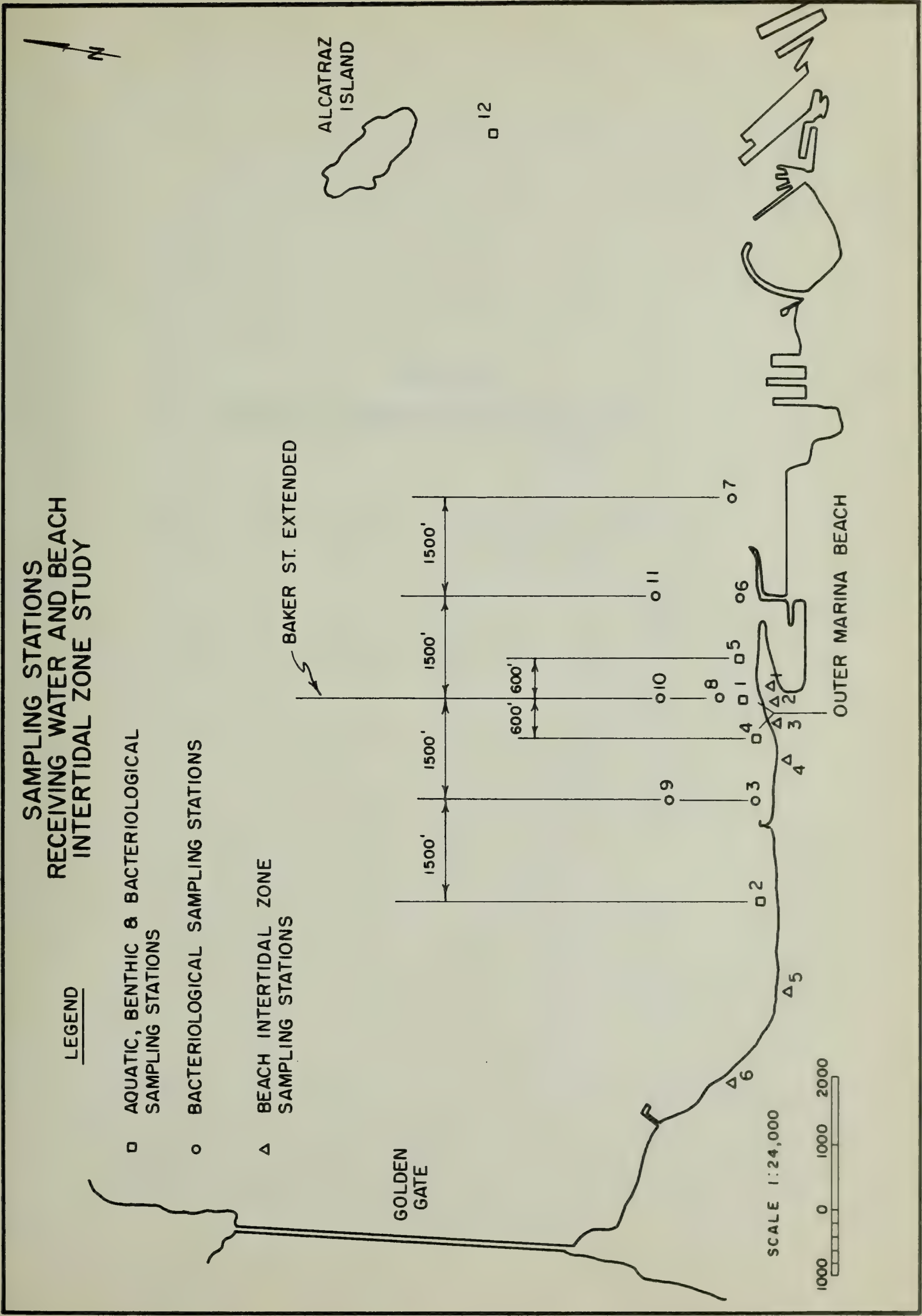
1. PUMP ACTUATED BY PRESSURE SWITCH ACTUATED BY RISING FLOW; MANUAL SHUTOFF
2. SAMPLE DISTRIBUTOR ROTATION: 1 REV/80 MINUTES
3. SAMPLING INTERVAL - 10 SEC EVERY 10 MIN FOR 80 MIN
4. SAMPLER CAPACITY - 8 SAMPLES AT 5 GAL EACH

FIGURE A-2

TEMPORAL VARIATION OF COLIFORM MPN LEVELS AFTER DAY WHEN RAINFALL EXCEEDED 0.02 INCH- AUGUST 1966 TO DECEMBER 1968



ENGINEERING-SCIENCE, INC.



SAMPLING STATIONS
RECEIVING WATER AND BEACH
INTERTIDAL ZONE STUDY

APPENDIX B

BAKER STREET DRAINAGE BASIN BASIC DATA

TABLE B-1

BAKER STREET DRAINAGE BASIN

SEWER SIZE DISTRIBUTION

Circular Sewer Diameter In Inches	Egg-shaped Sewer Size in Feet and Inches (Width x Depth)	Length in Feet	Percent of Total Sewer Length	Cumulative Percent of Total Sewer Length
6		-	-	-
8		8,925	24.06	24.06
10		4,200	11.32	35.38
12		10,070	27.15	62.53
14		1,500	4.04	66.57
15		500	1.35	67.92
16		3,800	10.24	78.16
18		1,050	2.83	80.99
21		250	0.67	81.66
24		375	1.01	82.67
	2'-0"x3'-0"	2,400	6.47	89.14
30		-	-	-
	2'-6"x3'-9"	1,350	3.64	92.78
	3'-0"x4'-6"	-	-	-
	3'-6"x5'-3"	-	-	-
	4'-0"x5'-6"	1,325	3.58	96.36
60		1,350	3.64	100.00
		37,095	100.00	100.00

TABLE B-2

BAKER STREET DRAINAGE BASIN: DRY WEATHER FLOW AND CONCENTRATION DATA

19 - 20 May 1969

Characteristic Time	1230	1400	1600	1800	2000	2200	2400
(19 May)							
Flow, cfs	3.3	3.52	3.05	3.03	3.07	3.09	2.34
COD, mg/l	325	355	282	432	392	273	167
BOD, mg/l	108	-	75	-	180	-	35
Floatables, mg/l	1.73	2.17	1.87	5.33	58.33	0.70	0.30
Oil & Grease, (HEM), mg/l	34.3	12.5	30.8	67.7	218.8	108.6	56.4
Settleable Solids, ml/l	7.5	6.5	9.0	7.5	7.5	6.0	4.0
Total Susp. Solids, mg/l	118	160	110	192	204	124	92
Vol. Susp. Solids, mg/l	106	134	94	142	170	116	88
Part. Size Dist., % TSS retained on							
74 μ filter	28.9	46.5	48.5	42.3	60.9	57.1	95.8
14 μ filter	52.0	47.6	46.8	56.7	39.1	40.7	4.2
5 μ filter	5.2	4.5	2.3	1.0	-	-	-
0.45 μ filter	13.9	1.4	2.4	-	-	2.2	-
Nitrogen, total, mg/l	16.4	17.9	19.3	19.9	20.6	17.5	15.4
Nitrogen, NH_3-N, mg/l	6.3	4.8	8.2	7.5	9.0	7.0	7.7
O-Phosphate, mg/l PO_4 as P	6.6	6.8	6.6	3.7	7.2	3.5	3.3
Coliforms, total, MPN/100 ml	43×10^6	23×10^6	23×10^6	73×10^5	23×10^5	93×10^6	46×10^6
Coliforms, fecal, MPN/100 ml	36×10^5	36×10^5	91×10^5	36×10^5	36×10^5	36×10^5	46×10^6
Electrical conductivity, μmhos/cm^2	700	780	700	800	650	610	620
Alkalinity, mg/l as $CaCO_3$	223	226	238	387	224	204	218
pH							

TABLE B-2 (Cont'd)

BAKER STREET DRAINAGE BASIN: DRY WEATHER FLOW AND CONCENTRATION DATA

19 - 20 May 1969

Characteristic Time (20 May)	0200	0400	0600	0800	1000
Flow, cfs	1.44	1.29	1.51	3.54	3.30
COD, mg/l	87	61	110	366	300
BOD, mg/l	-	16	-	158	-
Floatables, mg/l	0.27	0.17	0.53	4.83	0.57
Oil & Grease, (HEM), mg/l	5.6	3.2	5.4	33.9	24.0
Settleable Solids, ml/l	1.4	0.8	6.0	6.0	4.5
Total Susp. Solids, mg/l	52	18	36	154	118
Vol. Susp. Solids, mg/l	40	16	34	140	104
Part. Size Dist., % TSS retained on					
74 μ filter	94.1	78.9	43.6	55.5	42.4
14 μ filter	5.9	21.1	56.4	38.2	50.4
5 μ filter	-	-	-	3.8	3.6
0.45 μ filter	-	-	-	2.5	3.6
Nitrogen, total, mg/l	9.2	6.4	10.0	21.8	21.2
Nitrogen, NH_3-N, mg/l	5.2	3.1	3.8	11.6	8.1
O-Phosphate, mg/l PO_4 as P	1.7	1.3	1.8	6.9	12.5
Coliforms, total, MPN/100 ml	43×10^5	43×10^5	75×10^5	91×10^5	91×10^5
Coliforms, fecal, MPN/100 ml	23×10^5	23×10^5	75×10^5	36×10^5	91×10^5
Electrical conductivity, μmhose/cm^2	570	560	570	680	690
Alkalinity, mg/l as $CaCO_3$	196	179	206	249	219
pH					

TABLE B-3

BAKER STREET DRAINAGE BASIN: DRY WEATHER MASS EMISSION DATA

19 - 20 May 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3-Nitrogen	Ortho-phosphate-P
1230	3.3	5,780	1,920	30.8	610	2,099	1,885	292	112	117
1400	3.52	6,750	-	41.2	237	3,035	2,542	340	91.1	129
1600	3.05	4,635	1,233	30.7	506	1,808	1,545	317	135	109
1800	3.03	7,055	-	87.0	1,106	3,135	2,319	325	122	60.5
2000	3.07	6,486	2,979	48.0	3,620	3,375	2,813	341	149	119
2200	3.09	4,546	-	11.7	1,808	2,065	1,932	291	117	58.3
2400	2.34	2,106	442	3.78	711	1,160	1,110	194	97.1	41.7
0200	1.44	675	-	2.10	43.5	404	310	71.4	40.4	13.2
0400	1.29	424	111	1.18	22.2	125	111	44.5	21.6	9.04
0600	1.51	895	-	4.30	43.9	293	277	81.4	30.9	14.6
0800	3.54	7,000	3,200	92.5	649	2,940	2,680	417	222	132
1000	3.30	5,350	-	10.2	427	2,100	1,855	378	144	222

TABLE B-4

BAKER STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

4 - 5 April 1969

Characteristic Time	2220	2230	2240	2250	2310	2400	0010
Flow, cfs	*	*	7.36	8.82	7.10	-	15.60
COD, mg/l	241	274	-	276	142	128	322
BOD, mg/l	80	-	66	-	-	-	-
Floatables, mg/l	4.4	7.0	8.7	8.5	6.2	10.5	2.8
Oil & Grease, (HEM), mg/l	36.8	28.1	23.0	22.5	9.6	18.2	6.2
Settleable Solids, ml/l	5.5	5.0	4.5	4.0	2.5	4.0	1.0
Total Susp. Solids, mg/l	155	60	115	160	115	275	340
Vol. Susp. Solids, mg/l	115	50	80	110	95	155	95
Part. Size Dist., % TSS retained on							
74 μ filter	31.1	15.8	31.2	22.0	17.6	54.0	8.9
14 μ filter	102.2	62.0	112.0	60.0	20.0	98.0	68.0
5 μ filter	20.0	-	-	8.0	-	-	58.0
0.45 μ filter	12.0	-	6.0	-	-	-	18.0
Nitrogen, total, mg/l	14.5	14.8	14.7	10.7	8.8	4.1	10.2
Nitrogen, NH_3-N, mg/l	3.0	3.8	3.8	2.1	2.3	0.6	2.0
O-Phosphate, mg/l PO_4 as P	3.3	3.0	1.9	0.8	1.1	1.05	0.8
Coliforms, total, MPN/100 ml	43×10^6	-	23×10^6	-	24×10^6	-	110×10^6
Coliforms, fecal, MPN/100 ml	23×10^6	-	91×10^5	-	24×10^6	-	24×10^6
Electrical conductivity, μmhos/cm^2	420	410	340	250	330	300	23,000
Alkalinity, mg/l as $CaCO_3$	152	-	120	-	-	-	-
pH	7.2	-	7.2	-	-	-	-

TABLE B-4 (Cont'd)

BAKER STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

4 - 5 April 1969

Characteristic Time	0030	0115	0140	0210	0230	0255	0330
Flow, cfs	15.74	-	3.26	6.87	6.19	4.66	5.30
COD, mg/l	70	68	49	46	41	49	29
BOD, mg/l	<5	-	-	-	-	<5	-
Floatables, mg/l	5.1	0.1	0.5	0.1	0.1	0.1	0.4
Oil and Grease, (HEM), mg/l	3.8	2.9	1.9	1.6	0.7	1.0	1.0
Settleable Solids, ml/l	0.7	1.0	0.7	0.5	0.5	0.5	0.5
Total Susp. Solids, mg/l	50	70	50	35	30	20	20
Vol. Susp. Solids, mg/l	45	40	20	25	20	15	15
Part. Size Dist., % TSS retained on							
74 μ filter	11.7	8.5	5.6	5.1	9.7	14.6	1.7
14 μ filter	8.0	10.0	8.0	18.0	10.0	24.0	2.0
5 μ filter	-	-	-	-	-	-	-
0.45 μ filter	-	-	-	-	-	-	-
Nitrogen, total, mg/l	3.6	4.55	3.85	2.5	2.7	1.75	2.05
Nitrogen, NH_3-N, mg/l	1.0	1.2	1.15	0.7	0.9	0.65	0.55
O-Phosphate, mg/l PO_4 as P	0.34	0.66	0.48	0.48	0.48	0.48	0.48
Coliforms, total, MPN/100 ml	-	93×10^5	-	110×10^5	-	110×10^5	-
Coliforms, fecal, MPN/100 ml	-	43×10^5	-	24×10^5	-	110×10^5	-
Electrical conductivity, μmhos/cm^2	320	540	730	520	510	360	240
Alkalinity, mg/l as $CaCO_3$	50.5	-	-	-	-	48.0	-
pH	7.3	-	-	-	-	7.1	-

TABLE B-4 (Cont'd)

BAKER STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

4 - 5 April 1969

Characteristic / Time	0400	0420	0440	0515	0540	0630
Flow, cfs	7.28	-	5.29	5.21	3.93	6.81
COD, mg/l	37	41	30	32	61	62
BOD, mg/l	-	-	-	-	-	14
Floatables, mg/l	0.6	0.1	0.4	0.7	0.4	0.3
Oil & Grease, (HEM), mg/l	1.6	1.5	1.8	0.7	2.6	1.4
Settleable Solids, ml/l	0.5	0.6	0.4	0.4	0.6	0.8
Total Susp. Solids, mg/l	45	50	45	35	45	50
Vol. Susp. Solids, mg/l	35	45	40	25	40	45
Part. Size Dist., % TSS retained on						
74 μ filter	4.2	6.1	3.3	3.8	6.2	9.2
14 μ filter	8.0	8.0	12.0	12.0	24.0	18.0
5 μ filter	-	4.0	18.0	16.0	-	4.0
0.45 μ filter	-	-	10.0	12.0	-	-
Nitrogen, total, mg/l	2.0	1.95	1.6	2.0	3.95	3.7
Nitrogen, NH_3-N, mg/l	0.5	0.4	0.3	0.2	0.3	0.5
O-Phosphate, mg/l PO_4 as P	0.40	0.34	0.32	0.44	-	-
Coliforms, total, MPN/100 ml	43×10^4	-	43×10^4	-	110×10^5	-
Coliforms, fecal, MPN/100 ml	15×10^4	-	43×10^4	-	110×10^5	-
Electrical conductivity, μmhos/cm²	170	215	175	206	203	170
Alkalinity, mg/l as $CaCO_3$	-	-	-	-	-	83.0
pH	-	-	-	-	-	7.1

NOTE: * Blank sample to check background fluorescence of sewage.

TABLE B-5

BAKER STREET DRAINAGE BASIN: WET WEATHER COMBINED MASS EMISSION RATES

4 - 5 April 1969

Time	Flow cfs	Mass Emission Rates, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3-Nitrogen	Ortho-phosphate-P
2240	7.36	-	2,618	344	914	4,560	3,170	582	150	75.3
2250	8.82	13,000	-	403	1,070	7,600	5,230	508	99.0	90.0
2310	7.10	5,340	-	238	367	4,400	3,630	337	88.0	42.1
2400	14.7	10,130	-	832	1,440	22,550	12,260	324	47.5	83.2
0010	15.6	27,100	-	236	521	28,600	7,987	858	167	67.3
0030	15.7	5,920	<424	432	322	4,230	3,810	304	84.0	28.8
0115	7.65	2,800	-	4.10	120	2,890	1,650	188	50.0	27.2
0140	3.26	860	-	9.00	33.4	872	350	67.7	20.0	8.44
0210	6.87	1,700	-	3.70	59.2	1,300	926	92.6	26.0	17.8
0230	6.19	1,370	-	3.33	23.3	1,000	667	90.0	30.0	16.0
0255	4.66	1,230	<126	2.52	25.2	503	377	44.0	16.3	12.1

TABLE B-6

BAKER STREET DRAINAGE BASIN: WET WEATHER NET MASS EMISSION RATES

4 - 5 April 1969

Time	Flow cfs	Net Mass Emission Rates, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3-Nitrogen	Ortho-phosphate-P
2240	7.36	-	1,317	332	-523	2,785	1,500	340	40.0	22.3
2250	8.82	9,500	-	390	-280	5,900	3,680	250	-10.0	39.0
2310	7.10	2,240	-	143	-795	2,850	2,190	91.0	-18.0	3.60
2400	-	8,030	-	828	-728	21,390	11,160	124	-49.5	41.0
0010	15.60	25,125	-	232	-129	27,500	6,962	670	74.0	27.8
0030	15.74	4,170	<14.0	428	-215	3,255	2,910	129	1.00	-5.40
0115	-	1,600	-	1.30	-168	2,190	1,040	63	-11.0	38.0
0140	3.26	-65.0	-	6.60	-117	322	-90.0	-32.3	-30.0	-6.64
0210	6.87	1,025	-	1.50	19.2	610	626	17.6	-12.5	4.80
0230	6.19	720	-	1.23	-11.7	655	442	15.0	-5.00	3.80
0255	4.66	655	-74.0	0.52	-4.80	228	157	-23.0	-15.2	0.10

TABLE B-7

BAKER STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

15 October 1969

Characteristic Time	0310	0320	0330	0340	0350	0400	0420
Flow, cfs	9.58	8.67	8.60	7.71	6.92	7.42	10.53
COD, mg/l	92	85	77	60	61	78	12.1
BOD, mg/l	-	16.8	-	16.4	-	-	-
Floatables, mg/l	1.06	.56	.60	.55	.36	.86	1.6
Oil & Grease, (HEM), mg/l	5.0	5.2	-	0.1	1.5	1.5	2.4
Settleable Solids, ml/l	1.0	.7	1.2	.7	.9	.7	2.4
Total Susp. Solids, mg/l	58	44	47	42	42	40	110
Vol. Susp. Solids, mg/l	32	26	27	24	25	25	53
Part. Size Dist., % TSS retained on							
74 μ filter	100.0	91.0	100.0	77.0	68.5	100.0	100.0
14 μ filter	0	9.0	0	23.0	31.5	0	0
5 μ filter	0	0	0	0	0	0	0
0.45 μ filter	0	0	0	0	0	0	0
Nitrogen, total, mg/l	4.6	3.7	4.1	4.4	3.0	4.7	5.0
Nitrogen, NH_3-N, mg/l	1.6	1.6	1.8	1.5	1.2	2.5	2.2
O-Phosphate, mg/l PO_4 as P	.64	.61	.69	.66	.69	.69	.69
Coliforms, total, MPN/100 ml	1.0×10^6	150×10^5	93×10^5	93×10^5	43×10^5	15×10^5	23×10^5
Coliforms, fecal, MPN/100 ml	7×10^5	15×10^5	-	$<4 \times 10^5$	2.1×10^5	-	2.3×10^5
Electrical conductivity, μmhos/cm^2	188	184	215	197	220	233	169
Alkalinity, mg/l as $CaCO_3$	50.9	45.1	41.2	46.7	45.1	55.1	39.0
Toxicity, % survival in undiluted sample				100			

TABLE B-7 (Cont'd)

BAKER STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

15 October 1969

Characteristic Time	0450	0511	0530	0550	0611	0640	0710
Flow, cfs	8.64	6.58	8.28	10.50	11.95	12.54	-
COD, mg/l	42	48	58	61	87	174	70
BOD, mg/l	19.2	-	24.9	-	-	40.9	-
Floatables, mg/l	0.66	0.46	0.36	-	0.53	0.20	0.43
Oil & Grease, (HEM), mg/l	5.1	-	3.9	-	-	-	14.4
Settleable Solids, ml/l	1.3	.5	.5	1.2	1.0	1.5	5.2
Total Susp. Solids, mg/l	61	30	32	80	66	61	207
Vol. Susp. Solids, mg/l	35	24	24	45	41	41	109
Part. Size Dist., % TSS retained on							
74 μ filter	100.0	100.0	100.0	100.0	75.6	100.0	17.6
14 μ filter	0	0	0	0	0	0	15.0
5 μ filter	0	0	0	0	24.4	0	7.0
0.45 μ filter	0	0	0	0	0	0	-
Nitrogen, total, mg/l	4.3	3.7	3.2	4.8	6.2	6.9	8.2
Nitrogen, NH_3-N, mg/l	2.3	2.2	1.1	2.2	2.0	1.9	1.7
O-Phosphate, mg/l PO_4 as P	0.89	0.66	1.16	0.91	0.64	1.02	0.08
Coliforms, total, MPN/100 ml	43×10^5	9.3×10^5	150×10^5	-	93×10^5	43×10^5	-
Coliforms, fecal, MPN/100 ml	2.3×10^5	4.3×10^5	9×10^5	-	15×10^5	15×10^5	-
Electrical conductivity, μmhos/cm^2	182	207	207	154	161	182	138
Alkalinity, mg/l as $CaCO_3$	41.8	47.3	50.9	32.7	38.4	38.4	38.4
Toxicity, % survival in undiluted sample						100	

TABLE B-8

BAKER STREET DRAINAGE BASIN: WET WEATHER COMBINED MASS EMISSION RATES

15 October 1969

Time	Flow cfs	Net Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3-Nitrogen	Ortho-phosphate-P
0310	9.58	4,800	-	54.6	258	3,000	1,655	237	82.7	33.1
0320	8.67	3,970	789	26.2	242	2,055	1,213	173	75.0	28.4
0330	8.60	3,562	-	27.8	-	2,180	1,250	191	83.4	32.0
0340	7.71	2,500	682	22.9	4.15*	1,746	997	183	62.3	27.2
0350	6.92	2,273	-	13.4	55.9	1,570	932	112	44.8	25.7
0400	7.42	3,160	-	34.4	60.0	1,620	1,002	188	100	27.6
0420	10.53	685	-	90.9	136	6,250	3,014	284	125	39.2
0450	8.64	1,958	893	30.5	237	2,840	1,630	201	107	41.3
0511	6.58	1,704	-	16.3	-	1,063	855	131	78.1	23.4
0530	8.28	2,590	1,111	16.1	174	1,429	1,073	143	49.1	51.7
0550	10.50	3,455	-	-	-	4,530	2,550	272	124	51.5
0511	11.95	5,620	-	34.2	-	4,260	2,641	399	129	41.3
0640	12.54	11,770	2,761	13.5	-	4,125	2,775	467	128	68.8

NOTE: * Not used.

TABLE B-9

BAKER STREET DRAINAGE BASIN: WET WEATHER NET MASS EMISSION RATES
15 October 1969

Time	Flow cfs	Net Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
0310	9.58	4,250	619	52.6	228	2,750	1,465	172	53.7	21.9
0320	8.67	3,450	-	24.2	217	1,835	1,043	111	47.7	17.9
0330	8.60	3,057	542	25.8	-	1,980	1,095	129	57.9	21.8
0340	7.71	2,020	-	21.0	-	1,596	857	126	38.3	17.2
0350	6.92	1,828	-	11.6	30.9	1,430	807	57.0	22.8	16.0
0400	7.42	2,730	-	32.7	35.9	1,500	892	136	79.0	18.4
0420	10.53	160	-	88.9	106	6,080	2,894	172	113.8	29.0
0450	8.64	1,188	743	27.7	207	2,630	1,450	131	81.0	29.3
0511	6.58	704	-	12.8	-	823	655	56.0	50.6	10.5
0530	8.28	1,340	-164	12.2	137	1,154	833	66.0	30.1	37.7
0550	10.50	1,885	-	-	-	4,230	2,280	84.0	93.0	38.0
0611	11.95	3,740	-	21.7	-	3,660	2,166	279	81.0	15.3
0640	12.54	8,720	-239	-16.9	-	2,625	1,675	267	32.0	13.8

TABLE B-10

BAKER STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA
5 November 1969

Characteristic Time	0400	0410	0420	0430	0440	0450	0500
Flow, cfs	81.8	43.2	29.4	30.6	21.9	11.2	9.88
COD, mg/l	626	183	176	209	210	261	212
BOD, mg/l	24.7	-	23.6	-	45.2		37.4
Floatables, mg/l	1.3	-	1.9	2.4	1.1	-	3.0
Oil & Grease, (HEM), mg/l	110.3	46.2	6.0	27.3	6.0	18.6	20.6
Settleable Solids, ml/l	1.3	1.7	3.5	1.7	4.0	4.9	4.0
Total Susp. Solids, mg/l	86	80	92	130	148	246	202
Vol. Susp. Solids, mg/l	54	44	58	58	82	120	114
Part. Size Dist., % TSS retained on							
74 µ filter	24.0	51.8	54.4	43.9	32.4	36.6	44.1
14 µ filter	57.0	37.9	33.9	41.8	59.0	55.7	48.6
5 µ filter	7.6	1.7	5.2	4.3	1.2	0	2.9
0.45 µ filter	11.4	8.6	6.5	10.0	7.4	21.7	4.4
Nitrogen, total, mg/l	9.6	5.6	6.4	5.8	8.6	10.3	10.9
Nitrogen, NH_3-N, mg/l	0.88	0.88	0.98	1.13	1.19	1.19	1.39
O-Phosphate, mg/l PO_4 as P	0.5	.5	.6	.8	.9	1.1	1.1
Coliforms, total, MPN/100 ml	23×10^6	15×10^6	23×10^6	9×10^6	23×10^6	9.3×10^6	23×10^6
Coliforms, fecal, MPN/100 ml	4×10^5	9×10^5	11×10^5	15×10^5	93×10^5	23×10^5	43×10^5
Electrical conductivity, µmhos/cm^2	132	127	140	152	148	189	236
Alkalinity, mg/l as $CaCO_3$	24.6	26.4	26.4	28.3	30.5	45.7	50.2
pH	6.6	6.6	6.6	6.7	6.9	6.9	6.9
Toxicity, % survival in undiluted waste		80				100	

TABLE B-10 (Cont'd)

BAKER STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

5 November 1969

Characteristic Time	0540	0610	0640	0710	0740	0810	
Flow, cfs	24.5	12.5	14.6	12.5	14.6	14.7	
COD, mg/l	158	94	103	115	151	137	
BOD, mg/l	-	13.3	-	30.9	-	41.0	
Floatables, mg/l	4.0	0.3	0.8	2.2	-	0.6	
Oil & Grease, (HEM), mg/l	12.9	6.4	10.5	10.5	12.2	7.5	
Settleable Solids, ml/l	1.6	0.9	2.0	1.5	3.1	4.5	
Total Susp. Solids, mg/l	104	52	49	40	79	81	
Vol. Susp. Solids, mg/l	65	34	29	27	57	57	
Part. Size Dist., % TSS retained on							
74 μ filter	49.7	32.0	30.5	74.3	55.1	72.0	
14 μ filter	39.1	51.0	49.1	11.4	13.5	21.8	
5 μ filter	1.9	3.4	8.2	8.6	13.5	-	
0.45 μ filter	9.3	13.6	12.2	5.7	17.9	6.2	
Nitrogen, total, mg/l	12.6	4.9	8.4	10.9	14.9	14.6	
Nitrogen, NH_3-N, mg/l	0.79	0.89	1.66	2.22	2.18	2.51	
O-Phosphate, mg/l PO_4 as P	.7	.7	.9	1.6	1.9	2.8	
Coliforms, total, MPN/100 ml	$21x10^6$	$24x10^6$	$7.5x10^6$	$15x10^6$	$46x10^6$	$4.3x10^6$	
Coliforms, fecal, MPN/100 ml	$2.3x10^5$	$21x10^5$	$1.5x10^5$	$21x10^5$	$15x10^5$	$2.8x10^5$	
Electrical conductivity, μmhos/cm^2	128	162	200	245	314	309	
Alkalinity, mg/l as $CaCO_3$	32.7	48.0	52.3	67.6	87.3	93.7	
pH	6.7	6.9	7.0	7.2	7.3	7.4	
Toxicity, % survival in undiluted waste					100		

TABLE B-11

BAKER STREET DRAINAGE BASIN: WET WEATHER COMBINED MASS EMISSION RATES

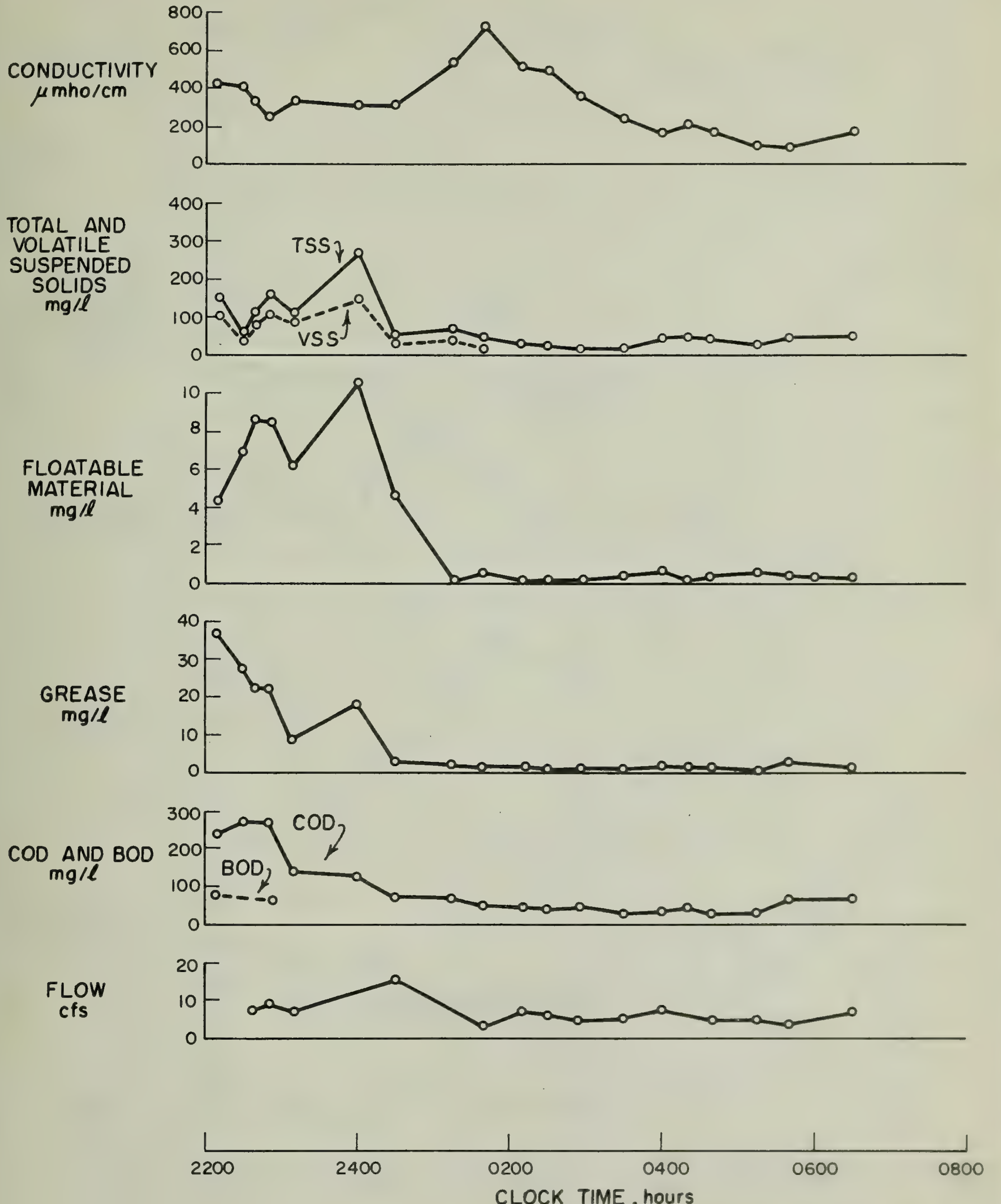
5 November 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
0400	81.8	276,200	10,900	574	48,700	37,990	23,850	4,240	388	220
0410	43.2	42,600	-	-	10,740	18,620	10,240	1,303	203	116
0420	29.4	27,850	3,740	301	950	14,570	9,180	1,014	156	95
0430	30.6	34,500	-	398	4,510	21,420	9,570	957	186	132
0440	22.0	24,820	5,200	130	710	17,500	9,700	1,015	140	106
0450	11.2	15,700	-	-	1,118	14,800	7,220	656	71.6	66
0500	9.88	11,300	1,990	160	1,097	10,760	6,070	580	74.0	58.5
0540	24.5	20,850	-	528	1,705	13,750	8,590	1,665	104	96.0
0610	12.4	6,300	895	20.2	430	3,495	2,282	329	58.5	47.0
0640	14.6	8,130	-	62.8	828	3,862	2,285	662	131	71.0
0710	12.4	7,720	2,070	148	704	2,682	1,813	731	149	107
0740	14.6	11,800	-	-	960	6,220	4,480	1,143	172	150
0810	14.6	10,800	3,240	47.0	592	6,380	4,490	1,143	198	218

TABLE B-12

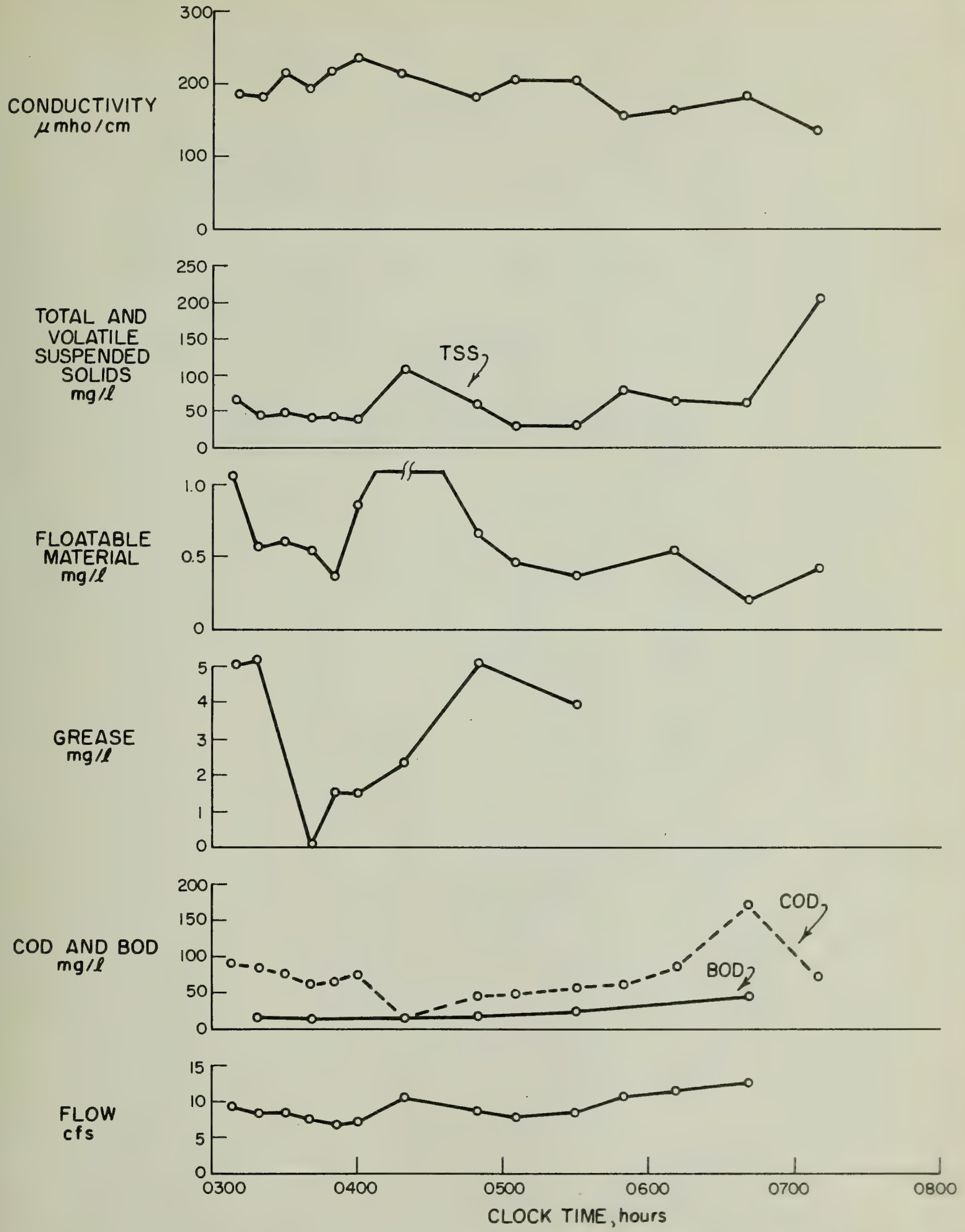
BAKER STREET DRAINAGE BASIN: WET WEATHER NET MASS EMISSION RATES
5 November 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
0400	81.8	275,770	10,800	572	46,675	37,865	23,735	4,185	367	211
0410	43.2	42,100			10,713	18,475	10,115	1,246	181	106
0420	29.4	27,325	3,390	299	921	14,400	9,050	955	148	84.8
0430	30.6	33,950		396	4,480	21,245	9,420	896	162	121
0440	21.9	24,220	4,500	128	676	17,310	9,540	950	115	94.5
0450	11.2	14,930			1,081	14,590	7,050	586	45.6	54.0
0500	9.88	10,400	1,090	157	1,058	10,530	5,890	505	47.0	46.2
0540	24.5	19,400		525	1,664	13,470	8,340	1,586	73.0	82.0
0610	12.5	4,420	-905	9.20	330	2,895	1,832	218	8.50	21.0
0640	14.6	5,080		28.8	590	2,612	1,185	462	31.0	15.0
0710	12.5	3,220	-530	92.0	341	782	113	456	5.00	23.0
0740	14.6	5,750			460	3,720	2,230	793	-18.0	56.0
0810	14.7	4,000	90	-38.0	104	3,505	1,865	733	-18.0	78.0



Note: See figure V-4 for rainfall data

CHARACTERISTICS OF COMBINED SEWER OVERFLOW
BAKER STREET SAMPLING SITE - 4 TO 5 APRIL 1969



Note: See figure V-4
for rainfall data

CHARACTERISTICS OF COMBINED SEWER OVERFLOW
BAKER STREET SAMPLING SITE - 15 OCTOBER 1969

APPENDIX C

MARIPOSA STREET DRAINAGE BASIN BASIC DATA

TABLE C-1

MARIPOSA STREET DRAINAGE BASIN
SEWER SIZE DISTRIBUTION

Circular Sewer Diameter In Inches	Eqq-shaped Sewer Size in Feet and Inches (Width x Depth)	Length In Feet	Percent of Total Sewer Length	Cumulative Percent of Total Sewer Length
6		200	0.49	0.49
8		4,925	11.96	12.45
10		925	2.24	14.69
12		14,675	35.64	50.33
14		-	-	-
15		4,020	9.75	60.08
16		2,150	5.23	65.31
18		2,550	6.20	71.51
21		1,825	4.43	75.94
24		1,050	2.54	78.48
	2'-0"x3'-0"	1,750	4.25	82.73
30		825	2.01	84.74
	2'-6"x3'-9"	2,850	6.93	91.67
	3'-0"x4'-6"	1,425	3.66	95.33
	3'-6"x5'-3"	1,925	4.67	100.00
	4'-0"x5'-6"	-	-	-
60		-	-	-
		41,095	100.00	100.00

TABLE C-2

MARIPOSA STREET DRAINAGE BASIN: DRY WEATHER FLOW AND CONCENTRATION DATA
2 - 3 June 1969

Characteristic Time	1400	1600	1800	2000	2200	2400	
Flow, cfs	0.91	0.88	0.78	0.76	0.77	0.62	
COD, mg/l	528	379	249	560	485	189	
BOD, mg/l	250	-	118	-	260	-	
Floatables, mg/l	4.52	4.8	7.3	9.6	8.3	1.3	
Oil & Grease, (HEM), mg/l	63.7	86.7	62.2	94.3	76.8	18.1	
Settleable Solids, ml/l	5.1	5.3	2.4	10.0	10.2	2.1	
Total Susp. Solids, mg/l	196	154	108	252	266	96	
Vol. Susp. Solids, mg/l	142	136	74	206	200	50	
Part. Size Dist., % TSS retained on							
74 μ filter	36.4	36.0	62.9	67.1	44.8	12.2	
14 μ filter	63.6	63.0	37.1	31.7	54.5	87.8	
5 μ filter	-	1.0	-	0.8	0.7	-	
0.45 μ filter	-	-	-	0.4	-	-	
Nitrogen, total, mg/l	32.1	23.3	22.2	27.2	27.0	20.9	
Nitrogen, NH_3-N, mg/l	9.6	9.9	10.2	10.0	10.4	10.4	
O-Phosphate, mg/l PO_4 as P	10.5	5.0	7.3	7.3	7.5	3.3	
Coliforms, total, MPN/100 ml	23×10^6	43×10^6	23×10^6	43×10^6	91×10^5	93×10^5	
Coliforms, fecal, MPN/100 ml	23×10^5	23×10^5	23×10^5	23×10^5	21×10^5	23×10^5	
Electrical conductivity, μmhos/cm^2	1200	685	560	540	650	540	
Alkalinity, mg/l as $CaCO_3$	204	215	172	125	207	125	
pH							

TABLE C-2 (Cont'd)

MARIPOSA STREET DRAINAGE BASIN: DRY WEATHER FLOW AND CONCENTRATION DATA

2 - 3 June 1969

Characteristic Time	0200	0400	0600	0800	1000	1200
Flow, cfs	0.38	0.35	0.40	0.80	0.92	0.99
COD, mg/l	286	129	129	294	369	294
BOD, mg/l	88	-	60	-	200	-
Floatables, mg/l	0.57	2.3	3.2	2.2	2.0	2.6
Oil & Grease, (HEM), mg/l	28.5	-	10.5	19.1	12.5	20.3
Settleable Solids, ml/l	0.75	0.15	3.7	6.5	6.0	4.0
Total Susp. Solids, mg/l	102	32	32	132	110	98
Vol. Susp. Solids, mg/l	32	8	22	108	78	62
Part. Size Dist., % TSS retained on						
74 μ filter	7.7	17.1	30.4	40.3	23.4	28.1
14 μ filter	92.3	73.7	69.6	52.5	68.1	67.1
5 μ filter	-	9.2	-	3.6	7.1	3.2
0.45 μ filter	-	-	-	3.6	1.4	1.6
Nitrogen, total, mg/l	14.4	14.5	13.2	37.6	34.3	28.2
Nitrogen, NH_3-N, mg/l	4.6	6.2	5.8	14.7	15.7	13.7
O-Phosphate, mg/l PO_4 as P	5.1	4.0	3.7	10.9	6.3	7.6
Coliforms, total, MPN/100 ml	43×10^5	110×10^6	43×10^6	43×10^6	23×10^6	21×10^6
Coliforms, fecal, MPN/100 ml	23×10^5	15×10^5	43×10^5	23×10^5	23×10^5	39×10^5
Electrical conductivity, μmhos/cm^2	980	725	550	780	860	850
Alkalinity, mg/l as $CaCO_3$	420	198	176	235	262	228
pH						

TABLE C-3

MARIPOSA STREET DRAINAGE BASIN: DRY WEATHER MASS EMISSION DATA
2 - 3 June 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
1400	0.91	2,590	1,230	22.3	312	961	696	157	47.1	51.5
1600	0.88	1,790	-	22.6	409	726	641	110	46.7	23.7
1800	0.78	1,050	492	30.7	262	454	311	93.0	42.9	30.3
2000	0.76	2,290	-	39.3	386	1,030	844	111	41.0	29.9
2200	0.77	2,010	1,080	34.4	319	1,100	830	112	40.2	31.1
2400	0.62	632	-	4.32	60.5	321	167	69.9	34.8	11.0
0200	0.38	586	164	1.2	58.4	209	65.0	29.0	9.4	14.3
0400	0.35	243	-	4.3	-	60.0	15.0	27.0	11.7	7.5
0600	0.40	278	129	6.9	22.6	69.0	47.0	28.0	12.5	8.0
0800	0.80	1,270	-	9.5	82.4	569	466	162	63.4	46.9
1000	0.92	1,830	990	9.9	62.0	545	387	170	77.8	27.7
1200	0.99	1,570	-	13.9	108	523	331	151	73.1	40.6

TABLE C-4

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

27 - 28 February 1969

Characteristic / Time	1750	1800	2027	2157	2203	2213	2223
Flow, cfs	2.78	2.29	3.22	1.30	3.43	14.82	14.45
COD, mg/l	12,800	131	129	127	114	119	103
BOD, mg/l	-	-	-	-	37	-	-
Floatables, mg/l	-	0.1	0.5	0.2	0.7	0.3	0.5
Oil & Grease (HEM), mg/l	1,327	2.1	5.4	7.3	8.1	19.3	7.7
Total Susp. Solids, mg/l	4,948	156	42	114	132	412	240
Vol.Susp. Solids, mg/l	4,420	20	4	42	54	126	56
Nitrogen, total, mg/l	13.9	9.0	6.0	6.3	6.3	5.9	2.3
Nitrogen, NH_3-N, mg/l	2.1	2.1	1.2	1.5	1.5	0.6	0.5
Total Phosphate, mg/l	10.0	-	-	-	2.4	-	-
Coliforms, total, MPN/100 ml	11×10^6	-	-	11×10^6	-	-	23×10^4
Coliforms, fecal, MPN/100 ml	11×10^6	-	-	24×10^5	-	-	23×10^4
Electrical Conductivity μmhos/cm^2	502	565	250	380	390	213	201
Toxicity, 96-hr TL_m, %	0	>100	>100	>100	-	-	-

TABLE C-4 (Cont'd)

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

27 - 28 February 1969

Characteristic Time	2233	2243	2253	2303	2313	2333	2353
Flow, cfs	13.10	11.20	6.65	6.16	13.2	7.32	5.75
COD, mg/l	124	123	117	129	110	61	66
BOD, mg/l	-	.44	-	-	-	14	-
Floatables, mg/l	0.4	0.3	0.3	0.2	0.2	1.9	1.4
Oil & Grease (HEM), mg/l	3.4	3.2	7.5	4.4	2.3	3.2	3.0
Total Susp. Solids, mg/l	240	208	150	158	184	92	106
Vol. Susp. Solids, mg/l	90	84	56	56	76	56	68
Nitrogen, total, mg/l	3.3	2.8	3.3	2.8	3.8	3.8	3.0
Nitrogen, NH_3-N, mg/l	0.6	0.6	0.8	0.6	0.3	0.2	0.3
Total Phosphate, mg/l	-	2.0	-	-	-	1.2	-
Coliforms, total, MPN/100 ml	-	-	46×10^5	-	-	75×10^4	-
Coliforms, fecal, MPN/100 ml	-	-	24×10^5	-	-	43×10^4	-
Electrical Conductivity µmhos/cm^2	218	263	231	223	161	160	225

TABLE C-4 (Cont'd)

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA
27 - 28 February 1969

Characteristic Time	0013	0043	0113	0143	0213	0243	0318
Flow, cfs	5.92	3.32	5.75	10.05	4.21	9.65	3.42
COD, mg/l	16	-	53	52	29	35	88
BOD, mg/l	-	-	11	-	-	-	31
Floatables, mg/l	0.8	1.3	0.8	0.6	0.6	0.3	0.3
Oil & Grease (HEM), mg/l	2.0	1.2	2.7	1.6	1.2	1.2	8.2
Total Susp. Solids, mg/l	104	56	64	-	36	-	66
Vol. Susp. Solids, mg/l	88	8	22	-	20	-	40
Nitrogen, total, mg/l	1.9	2.4	1.8				
Nitrogen, NH_3-N, mg/l	0.2	<0.1	0.2	<0.1	<0.1	<0.1	<0.1
Total Phosphate, mg/l	-	-	1.6	-	-	-	2.4
Coliforms, total, MPN/100 ml	-	23×10^4	-	-	93×10^4	-	-
Coliforms, fecal, MPN/100 ml	-	23×10^4	-	-	23×10^4	-	-
Electrical Conductivity μmhos/cm^2	200	240	215	220	193	144	230

TABLE C-4 (Cont'd)

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA
27 - 28 February 1969

Characteristic Time	0350	0413	0513	0613
Flow, cfs	6.76	3.58	13.90	3.52
COD, mg/l	184	32	23	29
BOD, mg/l	-	-	-	10
Floatables, mg/l	10.9	0.6	1.2	-
Oil & Grease (HEM), mg/l	47.8	1.1	1.5	0.8
Total Susp. Solids, mg/l	76	40	-	32
Vol. Susp. Solids, mg/l	50	20	-	22
Nitrogen, total, mg/l	-	-	-	-
Nitrogen, NH_3-N, mg/l	<0.1	<0.1	<0.1	0.3
Total Phosphate, mg/l	-	-	-	0.8
Coliforms, total, MPN/100 ml	$43x10^4$	-	-	$93x10^4$
Coliforms, fecal, MPN/100 ml	$23x10^4$	-	-	$23x10^4$
Electrical Conductivity µmhos/cm^2	225	238	165	259

NOTES: 1. Overflow started 2130 hours and ended 0600 hours.

2. Sample 1 taken at surface; samples 2 to 25 taken ~ 6 in. from bottom of sewer.

TABLE C-5

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED MASS EMISSION RATES
27 - 28 February 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
2127	3.22	2,240	-	8.70	94.0	730	68.0	105	21.0	-
2157	1.30	890	-	1.40	51.0	801	295	44	10.5	-
2203	3.43	2,120	684	13.0	151	2,440	1,000	116	29.0	44.3
2213	14.8	9,520	-	24.1	1,550	32,300	10,100	473	48.0	-
2223	14.5	8,010	-	39.2	600	18,700	4,380	179	38.0	-
2233	13.1	8,760	-	28.3	240	16,950	6,390	232	42.0	-
2243	11.2	7,420	26.6	18.2	190	12,600	5,100	169	36.0	121
2253	6.65	4,190	-	10.8	270	5,360	2,000	118	29.0	-
2303	6.16	4,280	-	6.70	147	5,250	1,870	93.0	19.0	-
2313	13.2	7,850	-	14.3	164	13,150	5,420	270	21.0	-
2333	7.32	2,400	552	75.1	126	3,630	2,200	152	7.0	47.3
2353	5.75	2,060	-	43.6	93.0	3,280	2,120	93.0	10.0	-

TABLE C-5 (Cont'd)

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED MASS EMISSION RATES

27 - 28 February 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
0013	5.92	510	-	25.6	65.0	3,320	2,800	61.0	6.0	-
0043	3.32	-	-	23.4	21.0	1,010	143	44.0	<1.79	
0113	5.57	1,540	340	24.9	84.0	2,000	680	55.8	6.0	49.6
0143	10.1	2,820	-	32.6	88.0	-	-	-	<5.0	-
0213	4.21	670	-	13.7	27.0	820	460	-	<2.30	-
0243	9.65	1,830	-	15.7	63.0	-	-	-	<5.2	-
0320	3.42	1,730	570	5.5	150	1,220	744	-	<1.8	44.2
0350	6.76	6,700	-	400	1,740	2,780	1,830	-	<3.6	-
0413	3.58	630	-	11.7	21.0	780	380	-	<1.9	-
0513	13.9	1,730	-	90.5	114	-	-	-	<7.5	-
0613	3.52	550	190	-	15.0	610	419	-	5.7	15.1

TABLE C-6

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER NET MASS EMISSION RATES
27 - 28 February 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
2127	2.47	150	-	-25.8	-246	-350	-767	-7.0	-19.2	-
2157	0.54	-1,130	-	-31.1	-269	-299	-535	-68	-29.5	-
2203	2.67	140	-386	-19.0	-144	1,380	190	5.0	-10.7	14.3
2213	14.1	7,660	-	-5.4	1,270	31,300	9,350	366	8.5	-
2223	13.7	6,270	-	-11.7	330	17,800	3,670	75.0	-1.0	-
2233	12.3	7,120	-	3.8	-5	16,100	5,750	132	3.6	-
2243	10.4	5,880	-903	-4.8	-35	11,800	4,500	72.0	-2.0	99
2253	5.90	2,790	-	-8.9	75	4,650	1,470	25.0	-8.9	-
2303	5.41	2,960	-	-11.8	-0.31	4,580	1,390	4.0	-18.5	-
2313	12.5	6,680	-	-0.7	8	12,600	5,010	185	-16.0	-
2333	6.67	1,440	-178	64.1	8	3,150	1,890	73.0	-29.0	33.3
2353	5.15	1,190	-	37.1	28	2,960	1,920	21.0	-25.5	-

TABLE C-6 (Cont'd)

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER NET MASS EMISSION RATES
27 - 28 February 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
0013	5.92	-120	-	21.6	5	3,010	2,550	-4.0	-26.0	-
0043	3.32	-	-	20.1	-39	735	13	-11.0	-23.2	-
0113	5.75	935	5	22.4	24	1,750	575	11.6	-13.0	36.6
0143	10.05	2,320	-	30.8	31	-	-	-	-7.50	-
0213	4.21	145	-	12.3	-27	636	401	-	-7.45	-
0243	9.65	1,370	-	13.4	13	-	-	-	-4.80	-
0320	3.42	1,390	320	2.20	106	1,120	714	-	9.16	34.7
0350	6.76	6,425	-	396	1,700	2,710	1,810	-	8.20	-
0413	3.58	380	-	7.0	-16	716	361	-	10.1	-
0513	13.90	1,470	-	84.8	84	-	-	-	4.70	-
0613	3.52	160	10	-	-18	48	319	-	13.3	3.1

TABLE C-7

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

20 March 1969

Characteristic Time	1025	1050	1100	1110	1120	1130	1140
Flow, cfs	-	-	3.91	5.10	6.20	8.29	7.48
COD, mg/l	468	468	382	290	546	324	306
BOD, mg/l	114	-	87	-	77	-	-
Floatables, mg/l	4.8	3.1	2.7	1.8	3.3	4.4	3.0
Oil & Grease, (HEM), mg/l	80.0	73.6	63.6	6.3	34.6	31.3	56.2
Settleable Solids, ml/l	4.3	4.5	5.8	6.0	4.5	7.5	5.3
Total Susp. Solids, mg/l	207	360	240	244	433	306	313
Vol. Susp. Solids, mg/l	160	180	127	113	207	147	160
Part. Size Dist., % TSS retained on							
74 μ filter	20.4	33.6	15.7	14.1	17.3	56.0	24.7
14 μ filter	76.6	65.6	83.5	85.3	77.8	41.9	73.8
5 μ filter	0	0	0	0	1.1	0	0.8
0.45 μ filter	3.0	0.9	0.8	0.6	3.7	2.2	0.8
Nitrogen, total, mg/l	28.7	-	19.5	-	13.7	-	-
Nitrogen, NH_3-N, mg/l	11.9	-	8.1	-	4.4	-	-
O-Phosphate, mg/l PO_4 as P	4.4	-	1.6	-	1.8	-	-
Coliforms, total, MPN/100 ml	9.1×10^6	9.1×10^6	43×10^6	110×10^6	15×10^6	9.3×10^6	$>110 \times 10^5$
Coliforms, fecal, MPN/100 ml	9.1×10^6	9.1×10^6	23×10^6	21×10^6	15×10^6	2.1×10^6	$>110 \times 10^5$
Electrical conductivity, μmhos/cm^2	800	485	385	350	262	200	158
Alkalinity, mg/l as $CaCO_3$	341	181	136	106	102	68	58
pH	9.0	8.6	8.0	7.3	9.1	7.6	7.3

TABLE C-7 (Cont'd)

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA
20 March 1969

Characteristic Time	1150	1200	1230	1300	1330	1400	1500
Flow, cfs	7.69	12.20	6.45	4.59	10.58	14.00	2.90
COD, mg/l	264	263	237	162	158	340	132
BOD, mg/l	-	-	35	-	-	-	-
Floatables, mg/l	23.7	1.8	3.9	2.2	2.4	6.0	0.6
Oil & Grease, (HEM), mg/l	14.5	28.2	26.0	13.7	32.1	36.0	20.7
Settleable Solids, ml/l	3.5	5.5	7.0	1.5	6.5	1.0	3.0
Total Susp. Solids, mg/l	300	293	240	133	407	167	213
Vol. Susp. Solids, mg/l	147	167	133	53	147	67	73
Part. Size Dist., % TSS retained on							
74 μ filter	30.8	24.5	16.5	23.0	36.1	9.7	10.2
14 μ filter	69.2	75.5	77.5	77.0	56.2	81.2	85.7
5 μ filter	0	0	1.7	-	2.3	4.1	2.1
0.45 μ filter	0	0	4.3	-	5.4	5.1	2.1
Nitrogen, total, mg/l	-	-	7.2	-	-	-	-
Nitrogen, NH_3-N, mg/l	-	-	2.6	-	-	-	-
O-Phosphate, mg/l PO_4 as P	-	-	1.6	-	-	-	-
Coliforms, total, MPN/100 ml	46×10^5	46×10^5	110×10^5	7.5×10^5	-	9.3×10^5	46×10^5
Coliforms, fecal, MPN/100 ml	24×10^5	46×10^5	21×10^5	3.9×10^5	-	3.6×10^4	0.3×10^5
Electrical conductivity, μmhos/cm^2	165	250	138	199	3,100	244	338
Alkalinity, mg/l as $CaCO_3$	60	83	47	70	-	-	81
pH	7.7	7.2	7.2	8.1	1.9	4.2	9.0

TABLE C-7 (Cont'd)

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

20 March 1969

Characteristic Time	1600						
Flow, cfs	1.38						
COD, mg/l	150						
BOD, mg/l	54						
Floatables, mg/l	0.8						
Oil & Grease, (HEM), mg/l	21.8						
Settleable Solids, ml/l	0.1						
Total Susp. Solids, mg/l	127						
Vol. Susp. Solids, mg/l	40						
Part. Size Dist., % TSS retained on							
74 μ filter	-						
14 μ filter	-						
5 μ filter	-						
0.45 μ filter	-						
Nitrogen, total, mg/l	9.2						
Nitrogen, NH_3-N, mg/l	2.6						
O-Phosphate, mg/l PO_4 as P	1.8						
Coliforms, total, MPN/100 ml	46×10^5						
Coliforms, fecal, MPN/100 ml	46×10^5						
Electrical conductivity, μmhos/cm^2	306						
Alkalinity, mg/l as $CaCO_3$	83						
pH	8.9						

TABLE C-8

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED MASS EMISSION RATES
20 March 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
1100	3.91	8,050	1,840	57.0	1,350	5,060	2,680	419	171	33.7
1110	5.10	8,010	-	49.0	171	6,740	3,120	-	-	-
1120	6.20	19,100	2,570	122	1,270	15,900	7,570	495	162	60.2
1130	8.29	14,500	-	195	1,400	13,700	6,580	-	-	-
1140	7.48	12,400	-	122	2,260	12,600	6,450	-	-	-
1150	7.69	10,900	-	980	601	12,400	6,090	-	-	-
1200	12.20	17,300	-	118	1,860	19,100	11,000	-	-	-
1230	6.45	8,870	1,217	147	971	9,000	4,990	266	97.0	55.7
1300	4.59	4,000	-	55.0	339	3,270	1,310	-	-	-
1330	10.58	8,980	-	137	1,830	23,200	8,370	-	-	-
1400	14.00	26,500	-	468	2,810	13,000	5,230	-	-	-
1500	2.90	2,060	-	10.0	324	3,350	1,140	-	-	-
1600	1.38	1,460	402	5.95	164	1,220	381	87.0	24.0	13.4

TABLE C-9

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER NET MASS EMISSION RATES
20 March 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
1100	3.01	6,350	815	45.0	1,216	4,527	2,320	259	95.2	-3.3
1110	4.18	6,330		36.8	26	6,208	2,768			
1120	5.28	17,440	1,509	109	1,110	15,370	7,220	338	87.7	19.5
1130	7.34	12,860		182	1,231	13,200	6,240			
1140	6.53	10,780		109	2,078	12,075	6,110			
1150	6.72	9,305		966	409	11,900	5,755			
1200	11.20	15,730		104	1,655	18,600	10,670			
1230	5.70	7,030	87	131	736	8,370	4,565	114	30.5	7.7
1300	3.59	1,910		36.8	77	2,525	795			
1330	9.61	6,630		117	1,541	22,350	7,765			
1400	13.20	23,900		446	2,495	12,040	4,534			
1500	2.13	-110		-12.3	-34	2,510	470			
1600	0.63	-330	-458	-16.4	-236	495	-259	-23	-23	-10.1

TABLE C-10

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

2 April 1969

Characteristic — Time	1100	1120	1130	1140	1150	1200	1220
Flow, cfs	-	8.55	6.55	4.79	3.42	2.94	2.89
COD, mg/l	1010	902	893	480	410	470	347
BOD, mg/l	327	-	304	-	117	-	-
Floatables, mg/l	4.4	1.5	2.2	1.6	1.6	2.2	0.7
Oil & Grease, (HEM), mg/l	110	64.0	38.8	26.9	31.6	40.8	29.9
Settleable Solids, ml/l	19.0	10.5	7.5	3.9	3.5	3.3	1.5
Total Susp. Solids, mg/l	905	840	515	347	253	272	227
Vol. Susp. Solids, mg/l	353	367	213	147	60	133	80
Part. Size Dist., % TSS retained on							
74 μ filter	41.4	20.1	19.0	9.8	16.5	17.5	8.2
14 μ filter	58.6	72.5	77.5	75.5	83.5	82.5	70.0
5 μ filter	-	3.7	2.2	12.7	-	-	10.9
0.45 μ filter	-	3.7	1.3	2.0	-	-	10.9
Nitrogen, total, mg/l	25.0	25.4	18.0	13.4	12.5	13.0	14.2
Nitrogen, NH_3-N, mg/l	7.2	7.0	5.2	3.6	4.1	4.2	6.4
O-Phosphate, mg/l PO_4 as P	3.75	3.30	3.00	2.60	5.10	2.50	3.30
Coliforms, total, MPN/100 ml	39×10^6	75×10^6	15×10^6	75×10^5	93×10^5	93×10^5	93×10^5
Coliforms, fecal, MPN/100 ml	91×10^5	73×10^5	36×10^5	23×10^5	73×10^4	91×10^4	93×10^5
Electrical conductivity, μmhos/cm^2	780	-	325	-	300	-	-
Alkalinity, mg/l as $CaCO_3$	140	-	77	-	74	-	-
pH	6.9		6.3		6.4		

TABLE C-10 (Cont'd)

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA
2 April 1969

Characteristic Time	1230	1240	1250	1315	1330		
Flow, cfs	2.89	2.94	1.95	2.52	1.73		
COD, mg/l	351	327	321	587	1665		
BOD, mg/l	-	-	113	-	300		
Floatables, mg/l	1.3	0.7	0.6	2.4	6.7		
Oil & Grease, (HEM), mg/l	26.6	21.3	30.8	53.1	185.5		
Settleable Solids, ml/l	1.5	2.5	2.8	6.0	15.0		
Total Susp. Solids, mg/l	213	220	160	400	1380		
Vol. Susp. Solids, mg/l	80	80	74	187	740		
Part. Size Dist., % TSS retained on							
74 μ filter	6.3	12.6	3.4	23.6	32.2		
14 μ filter	87.4	83.8	66.0	71.5	67.8		
5 μ filter	3.4	2.7	15.8	3.7	-		
0.45 μ filter	2.3	0.9	14.8	1.2	-		
Nitrogen, total, mg/l	14.0	16.0	16.4	11.8	36.4		
Nitrogen, NH_3-N, mg/l	6.4	7.2	10.2	5.2	6.0		
O-Phosphate, mg/l PO_4 as P	3.9	3.6	3.3	5.7	11.4		
Coliforms, total, MPN/100 ml	$24x10^6$	$11x10^6$	$11x10^6$	$43x10^6$	$46x10^7$		
Coliforms, fecal, MPN/100 ml	$24x10^6$	$46x10^5$	$24x10^5$	$91x10^5$	$75x10^6$		
Electrical conductivity, μmhos/cm^2	-	-	820	-	580		
Alkalinity, mg/l as $CaCO_3$	-	-	181	-	211		
pH	-	-	8.3	-	6.5		

TABLE C-11

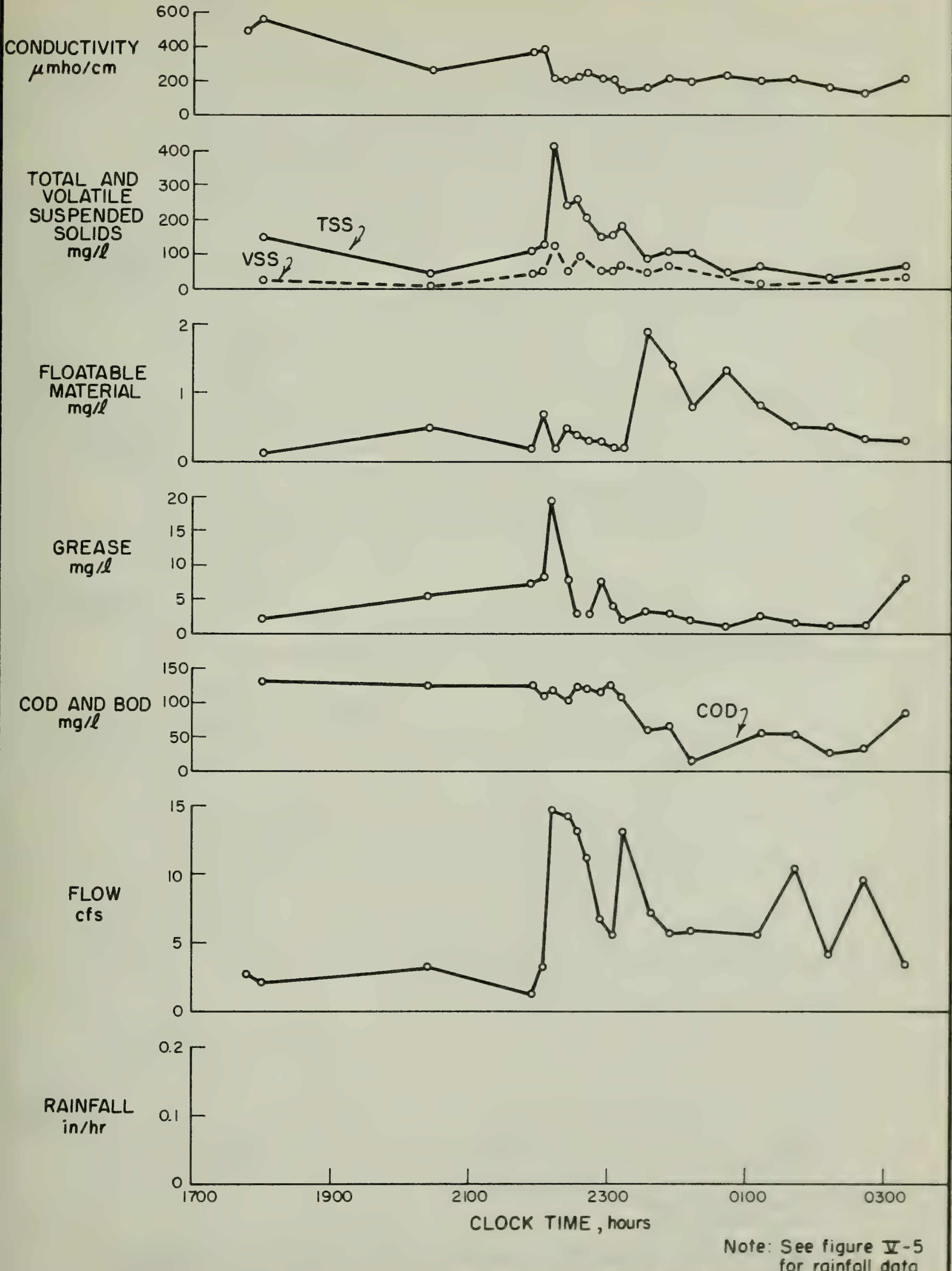
MARIPOSA STREET DRAINAGE BASIN: WET WEATHER COMBINED MASS EMISSION RATES
2 April 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
1120	8.55	41,500	-	69.0	3,000	38,700	16,900	1,170	320	152
1130	6.55	31,600	10,730	78.0	1,380	18,200	7,500	630	184	106
1140	4.79	12,400	-	42.0	700	8,900	3,800	350	93.0	67.2
1150	3.42	7,600	2,160	30.0	580	4,600	1,100	230	76.0	94.0
1200	2.94	7,500	-	35.0	650	4,300	2,200	210	67.0	39.7
1220	2.89	5,300	-	10.0	470	3,500	1,240	220	100	51.4
1230	2.89	5,500	-	10.9	420	3,300	1,240	220	100	60.7
1240	2.94	5,200	-	11.0	340	3,500	1,270	250	114	57.1
1250	1.95	3,400	1,190	6.30	350	4,200	1,960	124	54.5	59.3
1315	2.52	8,060	-	33.0	730	5,500	2,560	160	72.0	76.7
1330	1.73	15,600	2,790	63.0	1,730	12,900	6,900	340	56.0	106

TABLE C-12

MARIPOSA STREET DRAINAGE BASIN: WET WEATHER NET MASS EMISSION RATES
2 April 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
1120	7.63	39,800	-	56.4	2,840	38,200	16,550	1,010	278	111
1130	5.60	30,000	9,660	65.1	1,211	17,670	7,160	476	110	64.0
1140	3.83	10,800		29.0	520	8,380	3,460	196	19.2	23.2
1150	2.45	6,010	1,060	16.7	386	4,080	765	78.0	2.40	48.5
1200	1.94	5,930		21.1	445	3,780	1,870	59.0	-6.0	-7.3
1220	2.02	3,530		-5.5	212	2,900	840	68.0	31.5	3.4
1230	2.14	3,660		-5.1	150	2,670	815	68.0	33.6	12.4
1240	2.14	3,280		-5.9	53	2,830	810	97.0	49.8	8.6
1250	1.08	1,380	55	-11.1	97	3,490	1,480	-30.0	-7.5	10.3
1315	1.55	5,840		13.7	455	4,790	2,000	5.0	15.5	26.7
1330	0.78	13,300	1,600	42.5	1,440	12,050	6,300	184	2.5	55.7

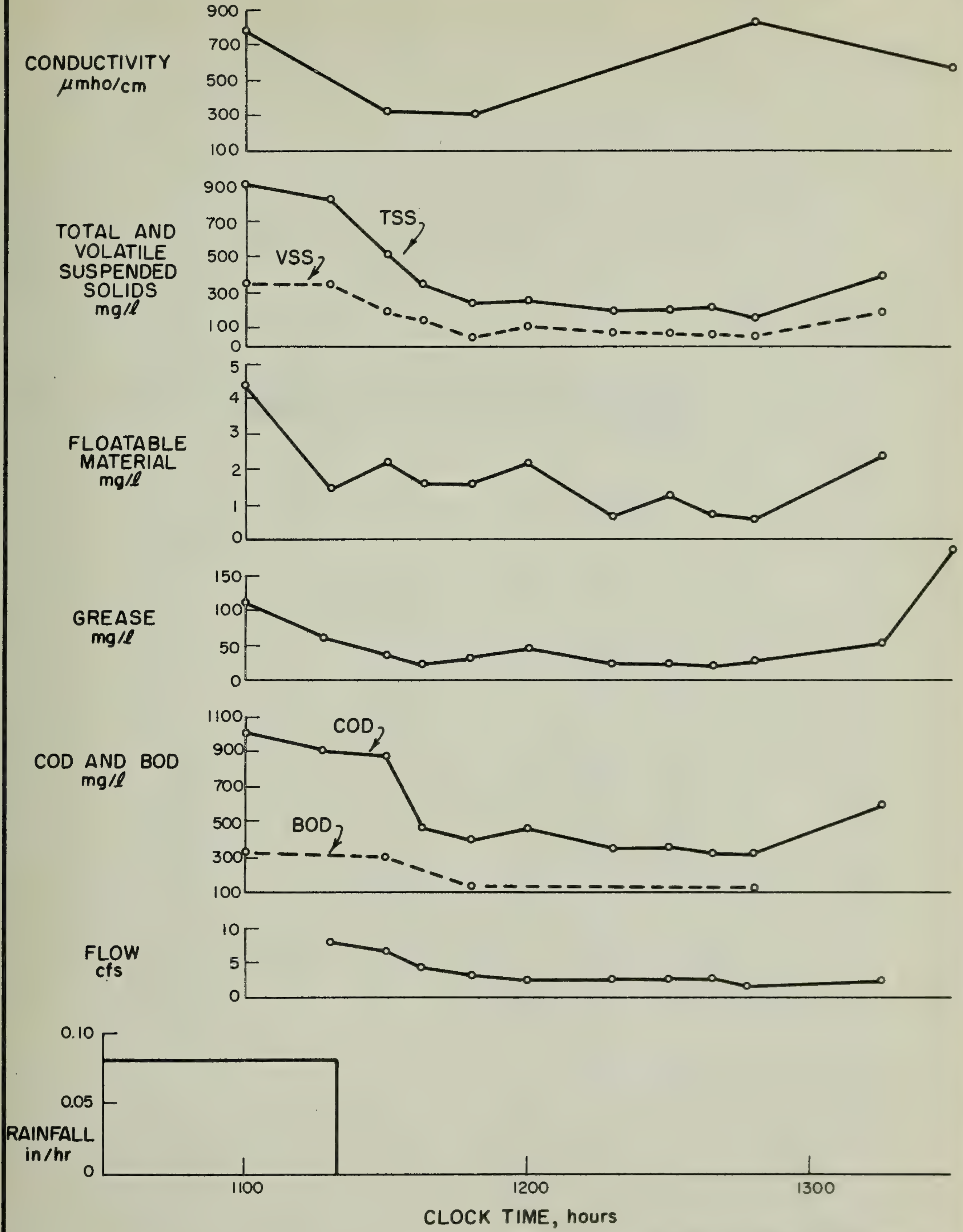


Note: See figure V-5 for rainfall data

CHARACTERISTICS OF COMBINED SEWER OVERFLOW
MARIPOSA STREET SAMPLING SITE- 27 TO 28 FEBRUARY 1969

ENGINEERING-SCIENCE, INC.

FIGURE C-2



Note: See figure V-5 for rainfall data

CHARACTERISTICS OF COMBINED SEWER OVERFLOW
MARIPOSA STREET SAMPLING SITE - 2 APRIL 1969

APPENDIX D

BROTHERHOOD WAY DRAINAGE BASIN BASIC DATA

TABLE D-1

BROTHERHOOD WAY DRAINAGE BASIN

SEWER SIZE DISTRIBUTION

Circular Sewer Diameter In Inches	Egg-shaped Sewer Size in Feet and Inches (Width x Depth)	Length in Feet	Percent of Total Sewer Length	Cumulative Percent of Total Sewer Length
6		2,630	5.28	5.28
8		18,600	37.38	42.66
10		-	-	-
12		21,200	42.59	85.25
14		-	-	-
15		1,960	3.94	89.19
16		-	-	-
18		530	1.06	90.25
21		1,070	2.15	92.40
24		940	1.89	94.29
	2'-0"x3'-0"	1,423	2.86	97.15
30		-	-	-
	2'-6"x3'-9"	1,421	2.85	100.00
	3'-0"x4'-6"	-	-	-
	3'-6"x5'-3"	-	-	-
	4'-0"x5'-6"	-	-	-
60		-	-	-
Total		49,774	100.00	100.00

TABLE D-2

BROTHERHOOD WAY DRAINAGE BASIN: DRY WEATHER FLOW AND CONCENTRATION DATA
16 - 17 June 1969

Characteristic Time	1300	1500	1700	1900	2100	2300
Flow, cfs	0.61	0.64	0.63	0.81	0.76	0.82
COD, mg/l	512	478	517	863	631	368
BOD, mg/l	230	-	288	-	275	-
Floatables, mg/l	4.8	6.6	63.6*	13.3	7.8	8.0
Oil & Grease, (HEM), mg/l	104	61.5	105	159	80.5	108
Settleable Solids, ml/l	16	12	14	11	10	11
Total Susp. Solids, mg/l	198	172	292	264	194	198
Vol. Susp. Solids, mg/l	178	148	278	234	174	168
Part. Size Dist., % TSS retained on						
74 μ filter	26.8	28.6	29.3	24.8	25.3	33.8
14 μ filter	48.5	41.8	41.5	54.0	18.5	46.1
5 μ filter	11.3	12.8	11.7	10.0	30.9	9.1
0.45 μ filter	13.4	16.8	17.5	11.2	25.3	11.0
Nitrogen, total, mg/l	32.4	34.0	44.0	39.2	33.8	41.0
Nitrogen, NH_3-N, mg/l	9.2	9.9	11.0	9.7	8.9	11.8
O-Phosphate, mg/l PO_4 as P	15.4	9.4	13.7	10.0	8.5	7.6
Coliforms, total, MPN/100 ml	23×10^6	43×10^6	43×10^6	43×10^6	43×10^6	23×10^6
Coliforms, fecal, MPN/100 ml	23×10^5	23×10^5	23×10^5	23×10^5	23×10^5	36×10^5
Electrical conductivity, μmhos/cm^2	625	500	580	520	445	445
Alkalinity, mg/l as $CaCO_3$	138	133	167	155	136	136
pH	7.2	7.5	7.6	7.1	7.5	7.6

TABLE D-2 (Cont'd)

BROTHERHOOD WAY DRAINAGE BASIN: DRY WEATHER FLOW AND CONCENTRATION DATA

16 - 17 June 1969

Characteristic Time	0100	0300	0500	0700	0900	1100	
Flow, cfs	0.31	0.20	0.67	0.82	0.77	0.81	
COD, mg/l	320	311	394	564	542	612	
BOD, mg/l	133	-	>175	-	225	-	
Floatables, mg/l	6.9	5.5	2.3	17.1	9.2	8.7	
Oil & Grease, (HEM), mg/l	55	32	95	132	176	86.2	
Settleable Solids, ml/l	14.0	3.5	9.0	16.0	19.0	12.0	
Total Susp. Solids, mg/l	134	72	292	264	301	282	
Vol. Susp. Solids, mg/l	114	64	270	198	276	238	
Part. Size Dist., % TSS retained on							
74 μ filter	41.9	26.4	37.6	28.2	16.5	25.4	
14 μ filter	34.0	41.6	42.6	56.5	55.3	56.5	
5 μ filter	14.2	15.3	9.9	6.7	10.7	18.1	
0.45 μ filter	9.9	16.7	9.9	8.6	17.5	0	
Nitrogen, total, mg/l	36.8	27.5	70.5	51.2	47.1	36.8	
Nitrogen, NH_3-N, mg/l	14.2	13.2	21.1	19.6	15.7	11.4	
O-Phosphate, mg/l PO_4 as P	6.3	4.4	6.6	9.0	9.8	11.3	
Coliforms, total, MPN/100 ml	23×10^6	93×10^6	46×10^6	15×10^7	15×10^7	23×10^6	
Coliforms, fecal, MPN/100 ml	23×10^5	91×10^5	15×10^6	36×10^5	23×10^5	23×10^5	
Electrical conductivity, μmhos/cm^2	460	385	500	525	545	565	
Alkalinity, mg/l as $CaCO_3$	140	127	176	182	148	140	
pH	7.8	7.9	7.9	7.7	7.6	7.6	

NOTE: * Oil in sample.

TABLE D-3

BROTHERHOOD WAY DRAINAGE BASIN: DRY WEATHER MASS EMISSION DATA
16 - 17 June 1969

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
1300	0.61	1,680	756	15.8	342	651	585	107	30.2	50.7
1500	0.64	1,650	-	22.8	212	593	511	117	34.2	32.4
1700	0.63	1,750	978	216*	357	992	945	149	37.4	46.5
1900	0.81	3,770	-	57.6	694	1,150	1,020	171	42.3	43.7
2100	0.76	2,580	1,130	32.0	330	795	713	138	36.4	34.8
2300	0.82	1,630	-	35.4	477	875	742	181	52.2	33.6
0100	0.31	535	222	11.60	92.0	224	191	61.4	23.7	10.5
0300	0.20	335	-	5.9	34.5	77.5	68.9	29.6	14.2	47.4
0500	0.67	1,420	>632	8.3	342	1,050	975	255	76.2	23.8
0700	0.82	2,490	-	75.5	583	1,170	874	226	86.5	39.8
0900	0.77	2,250	934	38.2	730	1,250	1,145	195	65.1	40.7
1100	0.81	2,670	-	38.0	376	1,230	1,038	161	49.7	49.2

NOTE: * Oil in sample.

TABLE D-4

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

14 January 1970

Characteristic Time	0100	0120	0140	0200	0230	0300	
Flow, cfs	27.0	43.7	8.34	4.86	3.78	10.6	
COD, mg/l	154	115	19.0	38.0	58.0	29.0	
BOD, mg/l	34.0	36.0	9.0	22.0	17.0	13.0	
Floatables, mg/l	21.7	37.0	13.6	4.7	2.1	4.0	
Oil & Grease, (HEM), mg/l	9.9	16.5	23.2	17.4	5.1	9.1	
Settleable Solids, ml/l	2.2	0.8	0.5	2.5	0.1	0.1	
Total Susp. Solids, mg/l	154	2165	271	670	58.0	87.0	
Vol. Susp. Solids, mg/l	107	1655	142	28.0	32.0	61.0	
Part. Size Dist., % TSS retained on							
74 μ filter	93.3	92.7	70.0	57.1	73.1	61.3	
14 μ filter	1.8	4.0	11.0	14.3	19.2	11.3	
5 μ filter	1.8	0.4	8.0	3.6	1.3	12.9	
0.45 μ filter	3.1	2.9	11.0	25.0	6.4	14.5	
Nitrogen, total, mg/l	17.8	10.7	11.4	15.8	13.4	6.9	
Nitrogen, NH_3-N, mg/l	0.28	0.47	0.61	0.51	1.49	0.21	
O-Phosphate, mg/l PO_4 as P	1.1	1.5	0.4	0.2	0.4	0.2	
Coliforms, total, MPN/100 ml	23×10^5	93×10^5	93×10^5	23×10^5	23×10^5	23×10^5	
Coliforms, fecal, MPN/100 ml	9.1×10^5	9.1×10^5	3.6×10^5	$<3 \times 10^5$	$<3 \times 10^5$	$<3 \times 10^5$	
Electrical conductivity, μmhos/cm^2	46.0	38.0	60.0	86.0	83.0	47.0	
Alkalinity, mg/l as $CaCO_3$	12.8	8.8	12.0	12.4	14.2	11.6	
pH	6.9	6.9	7.1	7.0	7.1	7.0	
Bioassay, % survival in Undiluted Waste	100				100		

TABLE D-4 (Cont'd)

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA
14 January 1970

Characteristic Time	0400	0430	0500				
Flow, cfs	1.78	2.80	1.90				
COD, mg/l	87.0	58.0	67.0				
BOD, mg/l	17.0	9.0	12.0				
Floatables, mg/l	2.5	2.2	3.8				
Oil & Grease, (HEM), mg/l	4.7	3.1	9.0				
Settleable Solids, ml/l	2.0	0.2	1.0				
Total Susp. Solids, mg/l	54.0	23.0	56.0				
Vol. Susp. Solids, mg/l	33.0	9.5	44.0				
Part. Size Dist., % TSS retained on							
74 μ filter	79.0	76.6	93.5				
14 μ filter	8.1	6.7	6.5				
5 μ filter	0.8	10.0	0				
0.45 μ filter	12.1	6.7	0				
Nitrogen, total, mg/l	18.8	17.1	22.3				
Nitrogen, NH_3-N, mg/l	2.3	1.6	2.9				
O-Phosphate, mg/l PO_4 as P	0.8	0.7	.9				
Coliforms, total, MPN/100 ml	$23x10^5$	$43x10^5$	$93x10^5$				
Coliforms, fecal, MPN/100 ml	$3.6x10^5$	$3.6x10^6$	$9.1x10^5$				
Electrical conductivity, μmhos/cm^2	96.0	104	106				
Alkalinity, mg/l as $CaCO_3$	17.2	12.0	17.2				
pH	7.1	7.0	7.0				
Bioassay, % survival in undiluted waste							

TABLE D-5

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER COMBINED MASS EMISSION RATES

14 January 1970

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
0100	27.0	22,400	4,930	3,160	1,430	22,400	15,500	2,580	40.7	160
0120	43.7	27,000	8,480	8,690	3,880	508,000	389,000	2,520	110	354
0140	8.34	854	404	612	1,040	12,180	6,380	512	27.4	18
0200	4.86	995	577	123	457	1,760	733	412	13.4	5.24
0230	3.78	1,180	346	42.7	103	1,180	652	272	33.0	8.15
0300	10.6	1,660	743	228	519	4,970	3,480	394	12.0	11.4
0400	1.78	836	1,630	24.0	45.2	518	317	181	22.1	7.67
0430	2.80	875	136	33.2	46.8	347	143	258	24.1	10.5
0500	1.90	687	104	39.0	92.3	574	452	229	29.7	9.22

TABLE D-6

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER NET MASS EMISSION RATES
14 January 1970

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
0100	26.7	21,900	4,710	3,150	1,340	22,200	15,300	2,520	17.0	149.5
0120	43.4	26,400	8,210	8,680	3,790	508,000	389,000	2,460	87.0	344
0140	8.09	374	104	603	968	12,000	6,250	462	5.4	9.5
0200	4.62	545	242	115	392	1,600	613	367	-6.6	-2.70
0230	3.56	780	-34	36.5	53	1,060	572	234	15.5	2.10
0300	10.4	1,320	316	222	484	4,890	3,411	364	-2.2	6.7
0400	1.60	-39	1,080	16.0	8.2	-32	-183	36	-22.9	-8.33
0430	2.61	-305	-464	25.7	48.2	-433	-557	55	-35.9	-8.5
0500	1.23	-763	526	30.5	248	-426	-448	-26	-45.3	14.3

TABLE D-7

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

15 January 1970

Characteristic / Time	1845	1855	1905	1915	1935	1945
Flow, cfs	10.8	5.98	9.30	11.4	9.48	21.2
COD, mg/l	43.0	57.0	107	64.0	55.0	26.0
BOD, mg/l	38.0	-	91.0	-	51.0	-
Floatables, mg/l	8.4	9.9	6.9	3.2	8.2	9.3
Oil & Grease, (HEM), mg/l	5.3	11.9	17.2	9.8	64.7	55.6
Settleable Solids, ml/l	0.8	0.9	1.0	1.2	0.9	0.6
Total Susp. Solids, mg/l	91	73	556	56	62	27
Vol. Susp. Solids, mg/l	30	31	515	32	41	13
Part. Size Dist., % TSS retained on						
74 μ filter	100	77.5	75.0	57.5	89.6	84.3
14 μ filter	0	11.3	9.2	8.2	10.4	9.8
5 μ filter	0	8.4	9.2	12.9	0	5.9
0.45 μ filter	0	2.8	6.6	9.4	0	0
Nitrogen, total, mg/l	16.9	25.1	28.4	21.7	21.4	13.8
Nitrogen, NH_3-N, mg/l	0.13	0.28	0.19	0.28	0.14	0.55
O-Phosphate, mg/l PO_4 as P	0.4	0.7	0.4	0.4	0.4	0.3
Coliforms, total, MPN/100 ml	15×10^5	46×10^5	110×10^5	3.6×10^5	46×10^5	15×10^5
Coliforms, fecal, MPN/100 ml	4.3×10^5	24×10^5	7.5×10^5	9.1×10^4	2.3×10^5	9.1×10^4
Electrical conductivity, μmhos/cm^2	55	82	78	70	72	53
Alkalinity, mg/l as $CaCO_3$	14	18	16	18	16	13
pH	6.6	6.5	6.3	6.3	6.3	6.3
Bioassay, % survival in undiluted waste	100			90		

TABLE D-7 (Cont'd)

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA
15 January 1970

Characteristic / Time	2015	2045	2115	2145	2215	2245	
Flow, cfs	5.69	2.92	2.37	3.73	3.48	5.01	
COD, mg/l	52.0	164	193	145	169	78.0	
BOD, mg/l	77	-	131	-	111	-	
Floatables, mg/l	6.2	47.6	6.5	5.1	6.0	5.6	
Oil & Grease, (HEM), mg/l	18.4	33.3	26.1	423.0	24.4	31.7	
Settleable Solids, ml/l	1.1	2.1	3.1	3.2	4.5	2.5	
Total Susp. Solids, mg/l	38	45	59	41	63	21	
Vol. Susp. Solids, mg/l	21	33	44	35	51	12	
Part. Size Dist., % TSS retained on							
74 μ filter	78.4	80.5	69.5	72.0	100	60.8	
14 μ filter	11.8	9.0	13.9	6.6	0	19.6	
5 μ filter	9.8	4.5	9.7	9.8	0	10.9	
0.45 μ filter	0	6.0	6.9	6.6	0	8.7	
Nitrogen, total, mg/l	20.8	45.9	17.3	38.0	55.5	23.7	
Nitrogen, NH_3-N, mg/l	0.34	1.9	6.1	1.5	5.5	0.44	
O-Phosphate, mg/l PO_4 as P	0.5	1.1	1.6	1.3	1.4	0.4	
Coliforms, total, MPN/100 ml	-	15×10^5	46×10^5	15×10^5	15×10^5	9.3×10^5	
Coliforms, fecal, MPN/100 ml	-	9.1×10^4	2×10^5	1.5×10^5	7.5×10^5	2.3×10^5	
Electrical conductivity, μmhos/cm^2	92	155	193	134	147	96	
Alkalinity, mg/l as $CaCO_3$	19	32	36	30	36	22	
pH	6.5	6.6	6.3	6.7	6.8	6.6	
Bioassay, % survival in undiluted waste						90	

TABLE D-8

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER
COMBINED MASS EMISSION RATES

15 January 1970

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
1845	10.8	2,500	2,210	488	308	5,280	1,750	97.4	7.55	23.3
1855	5.98	1,340	-	319	384	2,360	1,000	810	9.02	22.6
1905	9.30	5,370	4,560	346	861	27,900	25,800	1,420	9.51	20.0
1915	11.4	3,940	-	197	602	3,440	1,970	1,340	17.2	24.6
1935	9.48	2,810	2,610	418	3,300	3,170	2,090	1,090	7.16	20.4
1945	21.2	2,970	-	106	6,350	3,090	1,490	158	62.8	34.3
2015	5.69	1,590	2,360	190	563	1,160	644	637	10.4	15.3
2045	2.92	2,580	-	749	524	708	519	722	29.9	17.4
2115	2.37	2,430	1,670	83.0	334	754	562	221	77.8	20.5
2145	3.73	2,920	-	102	8,510	824	704	764	30.2	26.1
2215	3.48	3,170	2,090	113	458	1,180	958	1,040	103	26.2
2245	5.01	2,110	-	152	857	568	324	640	11.9	10.8

TABLE D-9

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER

NET MASS EMISSION RATES

15 January 1970

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3-Nitrogen	Ortho-phosphate-P
1845	9.97	-1,000	1,160	432	-342	4,130	745	-72.6	-35.0	-20.9
1855	5.16	-1,810	-	261	-296	1,200	0	638	-33.3	-21.4
1905	8.48	1,700	3,500	289	191	26,800	24,800	1,250	-33.0	-23.0
1915	10.6	360	-	142	-43	2,320	993	1,170	-25.3	-17.6
1935	8.60	-590	1,520	368	2,720	2,120	1,170	929	-34.8	-20.0
1945	20.4	-330	-	58	5,800	2,070	588	-2.0	20.8	-5.7
2015	4.94	-1,410	1,250	148	103	230	-186	487	-28.6	-22.7
2045	2.18	-145	-	714	154	-130	-231	579	-7.6	-18.6
2115	1.61	-18	590	50.8	-16	-54	-163	78	39.8	-14.5
2145	2.70	695	-	68.1	8,130	-16	-21	609	-13.8	-8.9
2215	2.67	1,200	975	79.0	38	313	228	877	57.0	-8.3
2245	4.19	360	-	116	397	-332	-416	465	-38.1	-23.5

TABLE D-10

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA

23 January 1970

Characteristic Time	0240	0308	0330	0350	0407	0431	0502
Flow, cfs	0.442	0.164	0.546	3.34	0.735	0.931	0.869
COD, mg/l	146	119	152	1252	88.0	72.0	90.0
BOD, mg/l	48.0	79.0	43.0	78.0	24.0	24.0	31.0
Floatables, mg/l	12.4	2.7	3.0	1415	5.7	3.3	2.2
Oil & Grease, (HEM), mg/l	9.7	11.6	7.0	139.0	6.0	5.7	6.9
Settleable Solids, ml/l	3.5	2.5	3.0	10.0	1.0	0.8	0.8
Total Susp. Solids, mg/l	42.3	42.0	44.0	5540.0	49.0	15.0	37.0
Vol. Susp. Solids, mg/l	38.3	37.5	38.0	5517.1	38.5	13.0	28.0
Part. Size Dist., % TSS retained on							
74 μ filter	-	-	-	-	-	-	-
14 μ filter	-	-	-	-	-	-	-
5 μ filter	-	-	-	-	-	-	-
0.45 μ filter	-	-	-	-	-	-	-
Nitrogen, total, mg/l	18.7	17.1	13.3	29.9	7.1	4.9	3.8
Nitrogen, NH_3-N, mg/l	1.02	0.85	0.52	0.14	0.37	0.54	1.04
O-Phosphate, mg/l PO_4 as P	1.28	1.30	0.75	1.93	0.51	0.74	1.15
Coliforms, total, MPN/100 ml	43×10^4	$>1100\times10^4$	460×10^4	$>1100\times10^4$	$>1100\times10^4$	240×10^4	150×10^4
Coliforms, fecal, MPN/100 ml	15×10^4	1100×10^4	36×10^4	$>1100\times10^4$	1100×10^4	240×10^4	150×10^4
Electrical conductivity, μmhos/cm^2	443	359	265	195	172	276	263
Alkalinity, mg/l as $CaCO_3$	62.4	61.3	45.2	40.4	27.8	31.2	35.3
pH	7.0	6.8	6.7	6.6	6.6	6.3	6.6
Bioassay, % survival in undiluted waste			100		100		

TABLE D-10 (Cont'd)

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER COMBINED FLOW AND CONCENTRATION DATA
23 January 1970

Characteristic	0529						
Flow, cfs	0.892						
COD, mg/l	187						
BOD, mg/l	60.0						
Floatables, mg/l	20.0						
Oil & Grease, (HEM), mg/l	9.6						
Settleable Solids, ml/l	7.0						
Total Susp. Solids, mg/l	110.0						
Vol. Susp. Solids, mg/l	101.7						
Part. Size Dist., % TSS retained on							
74 μ filter	-						
14 μ filter	-						
5 μ filter	-						
0.45 μ filter	-						
Nitrogen, total, mg/l	6.1						
Nitrogen, NH_3-N, mg/l	1.86						
O-Phosphate, mg/l PO_4 as P	2.46						
Coliforms, total, MPN/100 ml	> 1100×10^4						
Coliforms, fecal, MPN/100 ml	28×10^4						
Electrical conductivity, μmhos/cm^2	310						
Alkalinity, mg/l as $CaCO_3$	49.3						
pH	6.8						
Bioassay, % survival in undiluted waste	0						
96-hr TL_m %	86						

TABLE D-11

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER

COMBINED EMISSION RATES

23 January 1970

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
0240	0.442	348	114	295	23.1	101	91.2	44.6	2.43	3.02
0308	0.164	105	69.9	2.39	10.3	37.2	33.2	15.1	0.752	1.15
0330	0.546	443	129	8.82	20.6	129	112	39.1	1.53	2.21
0350	3.34	22,550	1,402	25,450	2,480	99,800	99,200	538	2.52	34.7
0407	0.735	348	95.1	22.6	23.8	194	152	28.1	1.46	2.02
0431	0.931	362	120	16.6	28.6	75.2	65.2	24.6	2.73	3.71
0502	0.869	422	145	10.3	32.3	177	131	17.8	4.87	5.38
0529	0.892	898	2.88	96.1	46.2	528	485	29.3	8.93	11.8

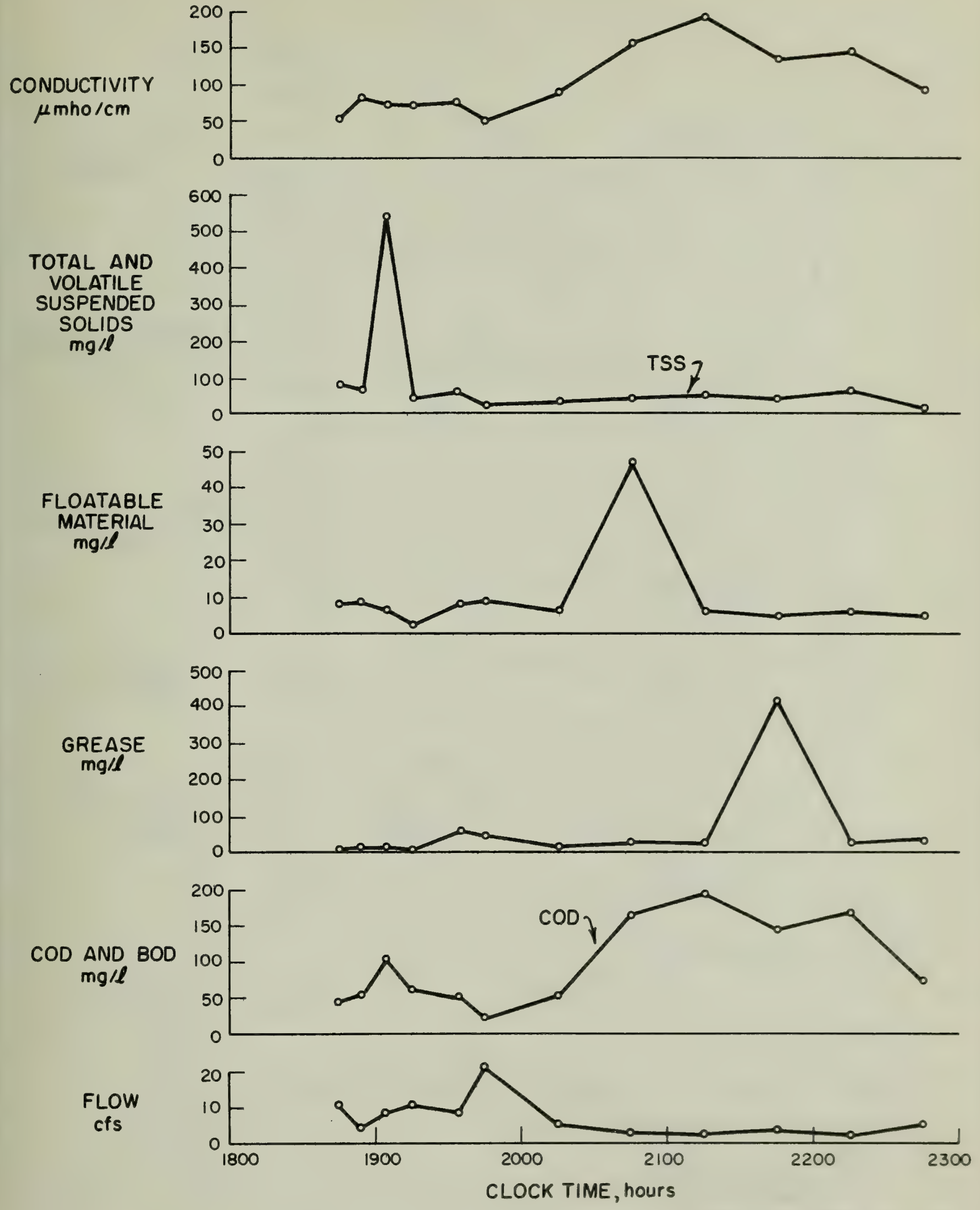
TABLE D-12

BROTHERHOOD WAY DRAINAGE BASIN: WET WEATHER

NET MASS EMISSION RATES

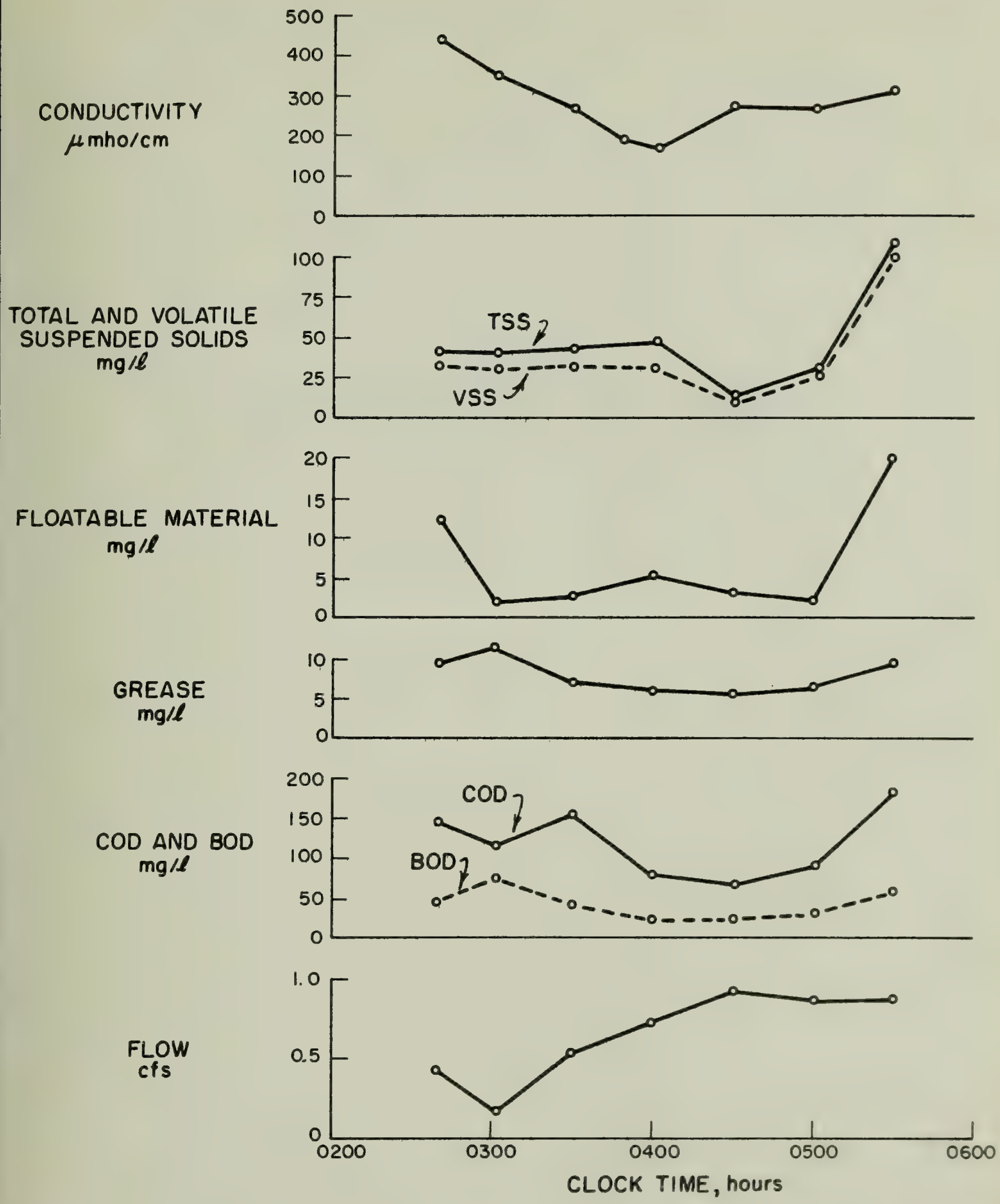
23 January 1970

Time	Flow cfs	Mass Emission Rate, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
0240	0.229	-37	-291	23.6	-21.9	1.0	21.2	0.6	-14.6	-2.98
0308	0.036	-345	-308	-2.81	-43.7	-92.8	-96.8	-34.9	-16.7	-5.35
0330	0.346	-182	-361	3.02	-89.4	-19.1	-158	27.1	-23.5	-97.8
0350	3.15	21,750	882	25,400	2,320	99,400	98,800	523	-37.5	22.0
0407	0.551	-652	-455	15.7	-186	-406	-368	20.1	-46.5	-14.0
0431	0.741	-808	-470	9.1	-239	-700	-525	-0.4	-59.3	-15.6
0502	0.199	-1,060	-485	-39.7	-316	-823	-769	-14.7	-72.1	-18.6
0529	0.233	-802	-667	34.0	-354	-512	-415	-12.7	-69.1	-15.7



Note: See figure V-6 for rainfall data

CHARACTERISTICS OF COMBINED SEWER OVERFLOW BROTHERHOOD WAY SAMPLING SITE- 17 JANUARY 1970



Note: See figure V-6 for rainfall data

CHARACTERISTICS OF COMBINED SEWER OVERFLOW
BROTHERHOOD WAY SAMPLING SITE - 23 JANUARY 1970

APPENDIX E

VICENTE STREET DRAINAGE BASIN BASIC DATA

TABLE E-1

VICENTE STREET DRAINAGE BASIN: SEWER SIZE DISTRIBUTION

Size Inches	Area 1		Area 2	
	Feet	Percent of Total length	Feet	Percent of Total length
8	2310	46.23	1430	30.36
12	1550	30.69	1440	30.57
15	330	6.53	310	6.58
18	250	4.95	900	19.11
21	610	12.08	630	13.38
	5050	100	4710	100

TABLE E-2

VICENTE STREET DRAINAGE BASIN,

AREA 1: WET WEATHER FLOW AND CONCENTRATION DATA

16 February 1970

Characteristic Time	1620	1635	1650	1705	1750	1820	
Flow, cfs	0.647	1.365	1.228	0.473	4.770	2.278	
COD, mg/l	428	235	107	80	63	51	
BOD, mg/l	98.1	37.6	17.0	13.4	-	5.6	
Floatables, mg/l	1.0	3.1	3.1	2.8	-	2.2	
Oil & Grease, (HEM), mg/l	7.6	17.9	6.0	5.7	-	7.6	
Settleable Solids, ml/l	5.70	1.40	0.60	0.35	-	0.40	
Total Susp. Solids, mg/l	210	103	61	30	68	26	
Vol. Susp. Solids, mg/l	77	46	27	16	25	10	
Part. Size Dist., % TSS retained on							
74 μ filter	88.1	80.5	74.4	76.0	-	89.2	
14 μ filter	5.9	8.9	12.8	15.2	-	4.3	
5 μ filter	5.4	5.3	5.1	4.4	-	4.3	
0.45 μ filter	0.6	5.3	7.7	4.4	-	2.2	
Nitrogen, total, mg/l	8.50	2.60	1.49	1.58	-	1.08	
Nitrogen, NH_3-N, mg/l	1.36	0.34	0.20	0.18	-	0.17	
O-Phosphate, mg/l PO_4 as P	0.77	0.08	0.13	0.10	-	0.08	
Coliforms, total, MPN/100 ml	43×10^5	21×10^4	11×10^5	29×10^4	-	46×10^4	
Coliforms, fecal, MPN/100 ml	23×10^5	21×10^4	3.6×10^4	9.1×10^4	-	9.1×10^4	
Electrical conductivity, μmhos/cm^2	600	360	250	254	-	113	
Alkalinity, mg/l as $CaCO_3$	15.3	42.0	10.5	11.6	-	7.35	
pH	6.4	6.5	6.5	6.5	-	6.7	
Bioassay, % survival in undiluted waste	30			90			

TABLE E-2 (Cont'd)

VICENTE STREET DRAINAGE BASIN, AREA 1

WET WEATHER FLOW AND CONCENTRATION DATA

16 February 1970

Characteristic Time	1850	1920	2000	2020	2050	2120
Flow, cfs	1.495	1.429	0.934	0.803	0.429	0.133
COD, mg/l	27	47	-	36	-	31
BOD, mg/l	-	5.8	-	3.1	-	4.5
Floatables, mg/l	-	1.8	-	3.3	-	2.9
Oil & Grease, (HEM), mg/l	-	4.5	-	10.5	-	12.0
Settleable Solids, ml/l	-	0.35	-	0.15	-	0.10
Total Susp. Solids, mg/l	26	24	-	20	-	28
Vol. Susp. Solids, mg/l	10	9	-	7	-	20
Part. Size Dist., % TSS retained on						
74 μ filter	-	69.2	-	62.1	-	40.6
14 μ filter	-	13.5	-	29.8	-	18.9
5 μ filter	-	15.4	-	2.7	-	18.9
0.45 μ filter	-	1.9	-	5.4	-	21.6
Nitrogen, total, mg/l	-	1.15	-	0.61	-	0.89
Nitrogen, NH_3-N, mg/l	-	0.28	-	0.12	-	0.26
O-Phosphate, mg/l PO_4 as P	-	0.10	-	0.09	-	0.11
Coliforms, total, MPN/100 ml	-	1.0×10^4	-	24×10^4	-	93×10^3
Coliforms, fecal, MPN/100 ml	-	9.3×10^4	-	23×10^3	-	23×10^3
Electrical conductivity, μmhos/cm^2	-	167	-	174	-	169
Alkalinity, mg/l as $CaCO_3$	-	6.30	-	12.6	-	9.45
pH	-	6.4	-	6.4	-	6.4
Bioassay, % survival in undiluted waste						100

TABLE E-3

VICENTE STREET DRAINAGE BASIN, AREA 1

WET WEATHER MASS EMISSION RATES

16 February 1970

Time	Flow cfs	Mass Emission Rates, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
1620	0.647	1,491	342	3.5	26.45	6.97	268	29.6	4.74	2.68
1635	1.37	1,730	277	22.8	132	758	338	191	2.50	0.59
1650	1.23	708	113	20.5	39.8	404	179	9.87	1.33	0.86
1705	0.473	204	34.3	7.14	146	76.7	40.9	4.04	0.461	0.26
1720	2.62									
1750	4.77	161				174	64.0			
1820	2.28	624	68.6	26.9	93.0	318	123	13.22	2.08	0.98
1850	1.49	218				209	80.5			
1920	1.43	362	44.6	13.9	34.6	185	69.3	8.9	2.2	0.8
2000	0.034									
2020	0.803	156	13.4	27.3	45.4	86.5	30.3	2.64	0.52	.39
2050	0.429									
2120	0.133	22.3	3.23	2.1	8.62	20.1	14.4	0.64	0.19	.08

TABLE E-4

VICENTE STREET DRAINAGE BASIN, AREA 2

WET WEATHER FLOW AND CONCENTRATION DATA

16 February 1970

Characteristic Time	1625	1640	1655	1710	1725	1755	1825
Flow, cfs	0.234	0.815	0.863	0.518	1.390	3.445	1.368
COD, mg/l	184	230	110	-	87	63	46
BOD, mg/l	20.2	19.5	8.0	-	6.1	-	1.7
Floatables, mg/l	7.4	3.7	6.2	-	2.6	-	5.8
Oil & Grease, (HEM), mg/l	21.5	12.3	11.0	-	6.6	-	17.8
Settleable Solids, ml/l	5.25	3.50	0.60	-	0.40	-	0.20
Total Susp. Solids, mg/l	210	160	67	-	70	54	37
Vol. Susp. Solids, mg/l	77	67	28	-	28	20	12
Part. Size Dist., % TSS retained on							
74 μ filter	94.5	92.2	87.2	-	90.2	-	76.8
14 μ filter	3.1	3.0	4.8	-	1.6	-	12.5
5 μ filter	0.6	1.2	3.2	-	3.3	-	7.1
0.45 μ filter	1.8	3.6	4.8	-	4.9	-	3.6
Nitrogen, total, mg/l	4.94	8.13	1.96	-	1.57	-	0.56
Nitrogen, NH_3-N, mg/l	4.10	4.84	0.56	-	0.28	-	<0.01
O-Phosphate, mg/l PO_4 as P	1.25	0.54	0.35	-	0.10	-	0.05
Coliforms, total, MPN/100 ml	23×10^5	23×10^4	23×10^5	-	93×10^3	-	93×10^3
Coliforms, fecal, MPN/100 ml	93×10^4	23×10^4	$<3 \times 10^3$	-	93×10^3	-	9.1×10^3
Electrical conductivity, μmhos/cm^2	600	525	525	425	324	-	144
Alkalinity, mg/l as $CaCO_3$	42.0	42.4	17.9	13.7	13.0	-	9.0
pH	6.8	6.5	6.4	6.5	6.4	-	6.1
Bioassay, % survival in undiluted waste	0	-	-	100	-	-	-

TABLE E-4 (Cont'd)

VICENTE STREET DRAINAGE BASIN, AREA 2
WET WEATHER FLOW AND CONCENTRATION DATA

16 February 1970

Characteristic Time	1855	1925	2005	2025	2055	2125	
Flow, cfs	1.91	1.28	0.95	0.652	0.395	0.092	
COD, mg/l	33.0	51.0		31.0		38.0	
BOD, mg/l		5.2		1.4		6.3	
Floatables, mg/l		3.8		1.7		1.2	
Oil & Grease, (HEM), mg/l		12.1		8.9		- -	
Settleable Solids, ml/l		0.15		0.05		0.04	
Total Susp. Solids, mg/l	26.0	28.0		21.0		11.0	
Vol. Susp. Solids, mg/l	10.0	9.0		6.0		5.0	
Part. Size Dist., % TSS retained on							
74 μ filter		98.0		81.4		73.6	
14 μ filter		0		6.2		5.3	
5 μ filter		2.0		6.2		21.1	
0.45 μ filter		0		6.2		0	
Nitrogen, total, mg/l		0.84		0.84		0.92	
Nitrogen, NH_3-N, mg/l		<0.01		0.14		0.22	
O-Phosphate, mg/l PO_4 as P		0.02		0.02		0.05	
Coliforms, total, MPN/100 ml		93×10^3		43×10^3		93×10^3	
Coliforms, fecal, MPN/100 ml		9.1×10^3		9.1×10^3		9.1×10^3	
Electrical conductivity, μmhos/cm^2		235		270		275	
Alkalinity, mg/l as $CaCO_3$		9.66		9.66		10.1	
pH		6.4		6.4		6.4	
Bioassay, % survival in undiluted waste							

TABLE E-5

VICENTE STREET DRAINAGE BASIN, AREA 2

WET WEATHER MASS EMISSION RATES

16 February 1970

Time	Flow cfs	Mass Emission Rates, lb per day								
		COD	BOD	Floatables	HEM	TSS	VSS	Total Nitrogen	NH_3^- Nitrogen	Ortho-phosphate-P
1625	0.234	232	25.4	9.32	27.1	264	97.0	6.22	5.16	1.574
1640	0.815	1,009	85.5	16.21	53.9	702	294	35.7	21.22	2.37
1655	0.863	512	37.19	28.8	51.2	311	130	9.11	2.60	1.625
1710	0.518									
1725	1.390	652	45.7	19.5	49.5	525	210	11.8	2.10	0.75
1755	3.445	1,170				1,004	372			
1825	1.368	338	12.52	42.7	131	27.2	88.4	4.12	<0.074	0.368
1855	1.910	339				268	103			
1925	1.278	351	35.8	26.15	83.2	193	61.9	5.78	<0.069	0.138
2005	0.950									
2025	0.652	109	4.93	5.98	31.3	73.8	21.09	2.95	0.493	0.070
2055	0.395									
2125	0.092	18.85	3.125	.060	-	5.46	2.48	0.457	0.109	0.025

APPENDIX F

SELBY STREET DRAINAGE BASIN BASIC DATA

TABLE F-1

SELBY STREET DRAINAGE BASIN
SEWER SIZE DISTRIBUTION

Circular Sewer Diameter In Inches	Egg-shaped Sewer Size in Feet and Inches (width x depth)	Length In Feet (Thousands)	Percent of Total Sewer Length	Cumulative Percent of Total Sewer Length
8		264.89	38.94	38.94
10		88.68	1.28	40.22
12		190.31	27.97	68.19
14		1.15	0.17	68.36
15		44.56	6.55	74.91
16		2.63	0.39	75.30
18		36.66	5.39	80.69
21		15.01	2.20	82.89
24		11.64	1.71	84.60
27		2.61	0.38	84.98
30		3.63	0.53	85.51
33		1.98	0.29	85.80
36		2.59	0.33	86.18
39		0.51	0.07	86.25
42		1.36	0.20	86.45
45		1.78	0.26	86.71
48		0.95	0.13	86.84
54		0.55	0.08	86.92
60		5.15	0.76	87.68
66		2.65	0.39	88.07
72		0.44	0.06	88.13
78		1.63	0.24	88.37
84		1.32	0.19	88.15
90		2.44	0.35	88.91
96		2.88	0.42	89.33
108		0.82	0.12	89.45
	2'-0"x3'-0"	9.61	1.41	90.86
	2'-4"x3'-6"	1.41	0.21	91.07

TABLE F-1 (Cont'd)

SELBY STREET DRAINAGE BASIN

SEWER SIZE DISTRIBUTION

Circular Sewer Diameter In Inches	Egg-shaped Sewer Size in Feet and Inches (width x depth)	Length in Feet (Thousands)	Percent of Total Sewer Length	Cumulative Percent of Total Sewer Length
	2'-6"x3'-9"	17.47	2.59	93.66
	3'-0"x3'-6"	0.50	0.07	93.73
	3'-0"x4'-6"	9.70	1.43	95.16
	3'-6"x5'-3"	5.25	0.77	95.93
	6'-0"x6'-0"	0.75	0.11	96.04
	6'-0"x10'-6"	0.50	0.07	96.11
	7'-6"x8'-3"	1.45	0.21	96.32
	7'-6"x9'-3"	1.02	0.15	96.47
	7'-6"x10'-0"	3.45	0.50	96.97
	8'-0"x10'-0"	0.80	0.11	97.08
	8'-1"x11'-3"	1.60	0.23	97.31
	8'-6"x12'-0"	0.69	1.01	98.32
	9'-0"x9'-6"	1.20	0.17	98.49
	9'-0"x11'-0"	10.01	1.47	99.96
Total		754.23	100.00	100.00

APPENDIX G

LAGUNA STREET DRAINAGE BASIN BASIC DATA

TABLE G-1

LAGUNA STREET DRAINAGE BASIN

SEWER SIZE DISTRIBUTION

Circular Sewer Diameter In Inches	Egg-shaped Sewer Size in Feet and Inches (width x depth)	Length in Feet	Percent of Total Sewer Length	Cumulative Percent of Total Sewer Length
6		650	0.86	0.86
8		6,640	8.77	9.63
10		1,480	1.95	11.58
12		15,570	20.58	32.16
14		4,230	5.67	37.83
15		2,480	3.28	41.11
16		19,220	25.39	66.50
18		9,820	12.97	79.97
21		2,400	3.18	82.65
24		940	1.24	83.89
	2'-0"x3'-0"	340	0.45	84.34
	2'-6"x3'-0"	460	0.61	84.95
	3'-0"x5'-0"	6,280	8.29	93.24
48		320	0.42	93.66
54		420	0.55	94.21
60		1,420	1.86	96.07
66		1,660	2.19	98.26
72		1,320	1.74	100.00
Total		75,710	100.00	100.00

APPENDIX H

SAMPLING OF FLOATABLE MATERIALS IN THE OCEAN

APPENDIX H

SAMPLING OF FLOATABLE MATERIALS IN THE OCEAN

INTRODUCTION

In the discharge of sewage into the ocean, coliform and floatables are the two most important indices of beach pollution. The collection of representative samples of floatable material, therefore, is an essential step in the monitoring or evaluation of submarine disposal of sewage.

Despite many attempts in recent years, no simple and dependable method of sampling has been devised. In a study by Merz for the California State Water Pollution Control Board (Reference H-1), several types of stationary floats were constructed and tested. The floats varied in form and methods of anchoring. They were filled with absorption pads through which known amounts of water were pumped. Oil and grease were retained by the pad and subsequently extracted with a suitable solvent. Although this type of sampler worked mechanically, several drawbacks have prevented its widespread use. Some of the drawbacks are:

(1) Cost of construction, operation, and maintenance is high.

(2) The sampler must be located near power supply but inaccessible to the public.

(3) The sampler pumps water not only from the surface but also from underneath the surface, and it is not possible to quantitate the grease and oil extracted in terms of weight per unit surface area.

(4) The method will not measure floatables of nongrease origin.

One other method commonly used in the field is the collection of floatables from the ocean surface by dipping a bucket and analyzing the sample for grease and oil. This method is inadequate because the areal concentration of floatables is generally very low, and the result cannot be expressed on the basis of surface area. Also, the disturbance of the water surface at the time of dipping may lead to erroneous results.

An ideal sampler for the collection of floatables should satisfy the following requirements:

(1) It should collect the sample from the surface only.

(2) The area of sampling should be known.

(3) It should be simple and dependable.

Floatable Sampling Apparatus

The sampler used during this study is a surface skimmer provided with a large net. Instead of relying on a pump or the ocean current for the throughput of sea water, it is to be trawled on the water surface by a boat. In order to have the sampler encounter undisturbed water surface, it is pulled away from the wake of the trawling boat by means of a paravane (or "otter board").

The sketch of the sampler and otter board are shown in Figure H-1. The prototype sampler consists of a wood frame, floats, and a net. The floats are attached in such a way that the sampler can maintain horizontal position while skimming a surface layer down to about 6 inches depth.

To impart a horizontal force in a right angle to the direction of the boat's movement, a 3 foot x 4 foot otter board was tested, initially. With proper floats and weights the planar otter board functioned well. However, when the waves were higher than two to three feet, the otter board tended to lose its stability. To resolve this problem, a trawling cone which was devised and patented by Fynbo (Reference H-2) was adapted for use instead, with excellent results.

Sampling Net

Several nets were made of cotton with 0.5 mm openings. The nets were 6 feet long, conically shaped and had a 1.5 foot x 2 foot opening. No significant clogging was observed and the sampler could be kept outside the wake of the boat without any observable deflection of the flow lines around the sampler.

The Efficiency of Collection by the Sampler

In order to estimate the fraction of floatables retained by the net with the 0.5 mm opening compared to the total floatable material, a test (Reference H-3) was conducted with effluent sewage from a primary settling basin. The result showed that 68 percent of the total weight of floatables was retained by the net while 32 percent of the total passed through the filter net.

Also, a test was made to find out whether the floatables in the path of the sampler will all pass through the openings of the sampler or be deflected. A special attachment was made to the sampler so that a uniform spread of small plastic pellets (3.0 mm in diameter) could be made during the time of skimming. A known number of polyethylene pellets were spread uniformly in six feet width, at four feet in front of the sampler (the sampler is two feet wide). By comparing the number of plastic pellets collected with the initial spread of the plastic pellets, the efficiency of collection was found to be 105 percent. The reason for collection of more than 100 percent of plastic pellets in the path of the sampler may be due to the water which hit the float at the side of the sampler and splashed over the side wall (6" high) into the sampler. This phenomenon could be observed during the test. To eliminate this possible cause, the height of the side wall was increased an additional eight inches. However, no further test was made to check the result of the correction.

Operation of the Sampler

In order to determine the concentration of floatables per unit area, the surface area covered by the sampling device must be measured.

The distance of surface travel by the sampler in relation to a hypothetical quiescent body of water (this means that the velocity of current has to be accounted for) may be found out by one of the two methods described below:

(1) Sampling a known distance twice, in opposite directions or along a closed curve around an outfall will allow determination of the distance of skimming regardless of the current velocity provided that the current velocity does not change greatly during the period of sampling.

(2) The use of a cumulative current meter (or odometer) attached to the side of the sampler will record the distance (relative to the quiescent body of water) of skimming covered by the sampler. This method does not necessitate the assumption of constant current velocity as above.

The connection of the sampler and otter board to the boat was made as shown in Figure H-2. The sampler is best operated at a speed between two and three knots. The wake of the boat used in this study spread out in a 15° angle, while the angle between the boat direction and the pulling line was about 30°.

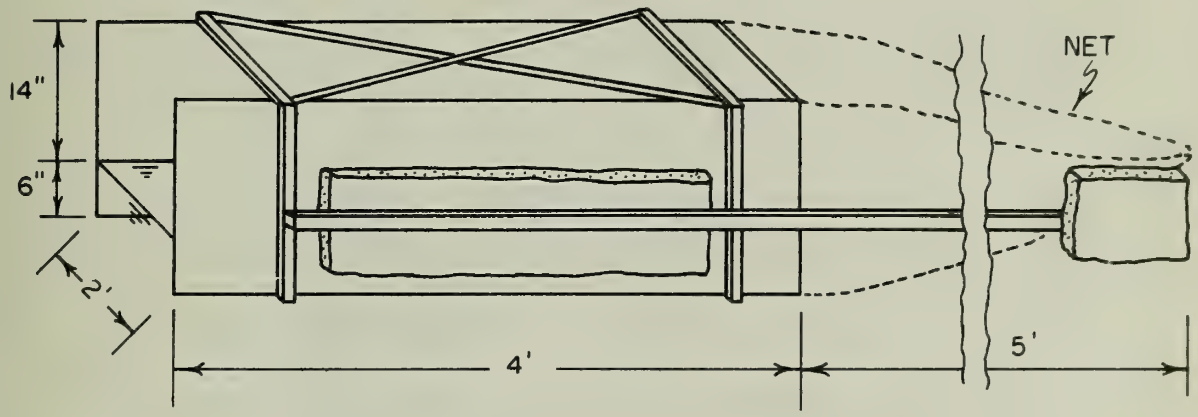
APPENDIX H - LIST OF REFERENCES

H-1 Merz, R.C., *"Determination of the Quantity of Oily Substances on Beaches and in Nearshore Wastes"*. Sanitary Engineering Research Laboratory, University of Southern California (1958).

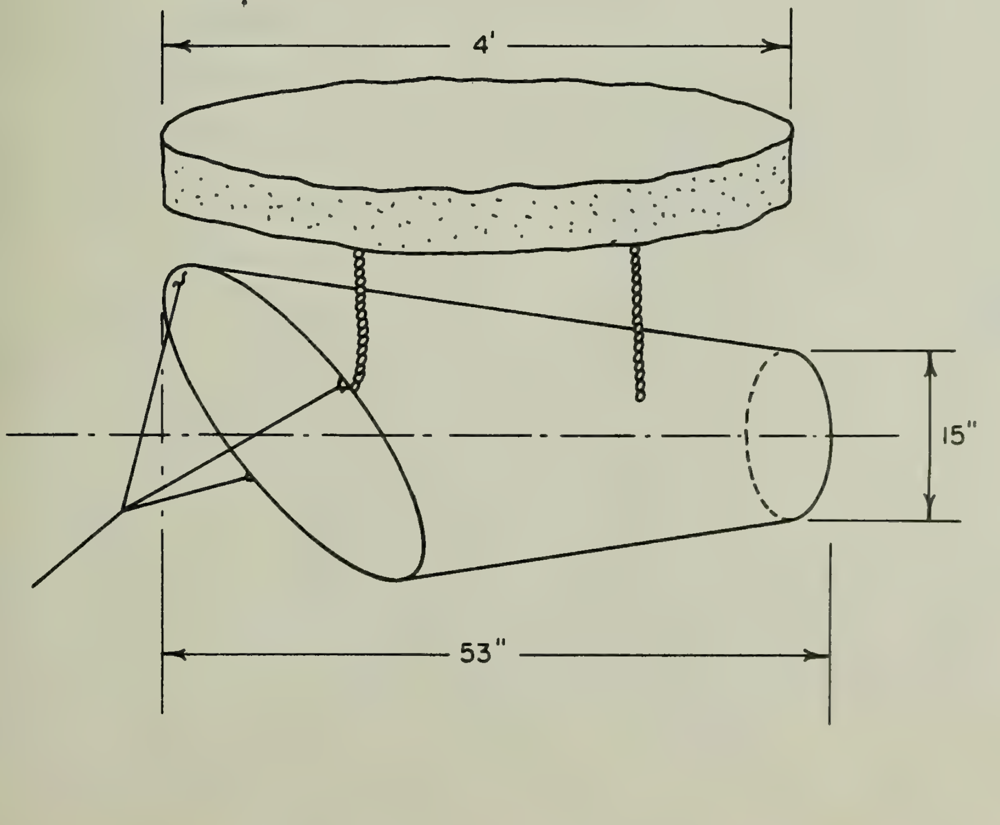
H-2 Fynbo, Hartman, *"Trawling Cone That Can Substitute for Otter Boards Invented in Denmark"*. Commercial Fishery Review 27:3, 40 (1965).

H-3 *"Determination and Removal of Floatable Material from Waste Water"* prepared for Division of Water Supply and Pollution Control, U.S. Public Health Service, by Engineering-Science, Inc. November 1965.

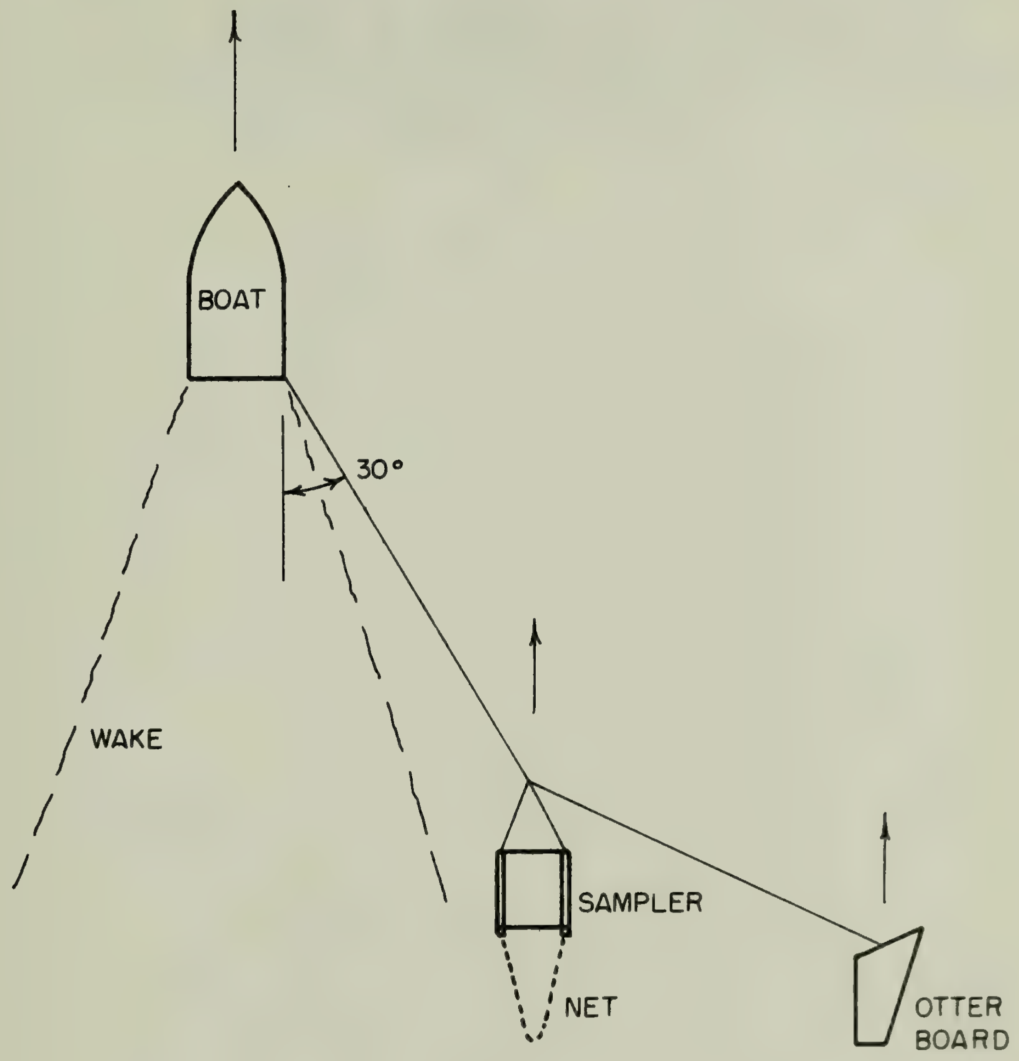
SKETCH OF FLOATABLES SAMPLER



SKETCH OF CONE SHAPED "OTTER BOARD"



SKETCH OF THE SAMPLER TRAWLING METHOD



APPENDIX I

BENTHIC ANIMAL DATA

(NOTE: Data for the February 1969 survey are expressed as number of organisms per liter of sediment. Data for the May 1969 and January 1970 surveys are expressed as number of organisms per sample volume. Sample volumes were not constant).

TABLE I-1

BENTHIC ANIMAL DATA, FEBRUARY SURVEY

Identification	Station 1	2	4	5	12
ANNELIDA					
OLIGOCHAETA	448	97	5	83.3	3.7
POLYCHAETA					
Pectinariidae			.25		
Terebellidae	.8			.75	
Magelonidae				.25	
Maldanidae	.8	.29			
Opheliidae	2		1	1.75	
Capitellidae		3.1		5.5	
Nephtyidae	.4		.25	.25	.29
Glyceridae	.4	2.6	1.5	3.5	.57
Unidentified	53	6.6	30	18.3	40
HIRUDINEA				.25	
ARTHROPODA					
COPEPODA (bottom form)			.25		
MALACOSTRACA					
Cumacea					
Diastylis sp.				.25	
COELENTERATA					
HYDROZOA				1.25	
ANTHOZOA					
Actinaria				.25	
Pennatulaceae					
Stylatula elongata					.29
NEMATODA	242	353		407	229
PORIFERA				.25	
SIPUNCULOIDEA					

TABLE I-2

BENTHIC ANIMAL DATA

MAY SURVEY

Identification	Station 1	4	5	12
ANNELIDA				
OLIGOCHAETA	9	11	117	4
POLYCHAETA				
Arenicolidae				
Arenicola pusilla	1			
Cirratulidae				
Cirratulus sp.			1	1
Glyceridae				
Glycera americana		7		
Glycera tesselata			1	
Hemipodus borealis		14		
Goniadidae				
Glycinde polygnatha	28	5	41	
Maldanidae				
Axiothella rubrocineta			1	1
Nephytidae				
Nephtys assignis	1			
Nephtys caecoides	11			
Nephtys californiensis	1			
Aglaophamus dicirris		31	1	
Opheliidae				
Polyophthalmus sp.	6			
Orbiniidae				
Haploscoloplos sp.			2	
Nainereis sp.			4	
Spionidae				
Polydora brachycephala			4	

TABLE I-2 (Cont'd)

BENTHIC ANIMAL DATA

MAY SURVEY

Identification	Station			
	1	4	5	12
Syllidae				
Syllis sp.		3		1
Typosyllis sp.	198			
Unidentified		2		
ARTHROPODA				
Amphipoda				
Gammaridae				
Eurystheus sp.			2	
Phoxocephalidae				
Pontharpina obtusidens	2		1	
Anomura				
Callianassa sp.		10	14	
Brachyura				
Cancer gracilis			1	
Pinnixa franciscana	3		3	
Pinnixa sp.			1	
Unidentified			2	
Cumacea	8		9	
BRYOZOA				
Cheilostomata				
Bugula pacifica		f		
Caulibugula sp.			f	
Ctenostomata				
Aeverrillia sp.		f	f	f
Triticella sp.			f	
COELENTERATA				

TABLE I-2 (Cont'd)

BENTHIC ANIMAL DATA

MAY SURVEY

Identification	Station 1	4	5	12
ANTHOZOA				
Actinaria				
Edwardsiella sp.		1		
Pennatulacea				
Stylatula elongata		f		
Unidentified			f	
HYDROZOA				
Hydroida				
Abietinaria sp.	f	f	f	
Aglaphenia sp.		f	f	
Campanularia sp.	f	f	f	
Obelia sp.	f		f	
Unidentified				f
ECHINODERMATA				
ASTEROIDEA				
Pisaster brevispinus		f		
ECHIUROIDEA				
Urechis caupo		1	3	3
MOLLUSCA				
PELECYPODA				
Macoma secta		11	9	
Mya arenaria	3	16		
Mytilus edulus		1		
Protothaca staminea	1	1		
Solen sp.				
Tellina bodegensis	3	4	8	

TABLE I-2 (Cont'd)

BENTHIC ANIMAL DATA
MAY SURVEY

Identification	Station			
	1	4	5	12
Tellina salmonea	2			
Transennella tantilla	3	11	3	
Tresus nuttalli		1		
Mysella sp.		1		
Volsella sp.			1	
Gastropoda				
Cylichna sp.			1	
Lacuna sp.			1	
Nassarius cooperi		1		
NEMATODA	385	26	276	6
NEMERTEA				1
PHORONIDEA				
Phoronis sp.		1	4	
SIPUNCULOIDEA				
Sipunculus sp.	1	3	4	
Unidentified		1		
Volume of Animals (ml)	2.80	4.36	1.82	0.14
Number of Animals	619	173	511	41
Number of Entries	22	30	33	10

NOTES: f = fragments.
Sample lost for Station 2.

TABLE I-3

BENTHIC ANIMAL DATA

JANUARY SURVEY

Identification	Station				
	1	2	4	5	12
ANNELIDA					
OLIGOCHAETA		2	17		1
POLYCHAETA					
Arabellidae					
Arabella iricolor		1	10		
Glyceridae					
Hemipodus borealis		8			
Glycera capitata	5				
Glycera convoluta			3	1	
Goniadidae					
Glycinde armigera				1	
Lumbrineridae					
Lumbrineris sp.				1	
Nephtyidae					
Aglaophamus sp.				1	
Nephtys caecoides			1		
Nephtys sp.			19		
Nereidae					
Species No. 1		4			
Species No. 2		1			
Opheliidae					
Armandia bioculata		3			
Unidentified		1			
Orbiniidae					
Haploscoloplos sp. #1		1	1	1	
Haploscoloplos sp. #2				1	
Scoloplos sp.				1	

TABLE I-3 (Cont'd)

BENTHIC ANIMAL DATA
JANUARY SURVEY

Identification	Station				
	1	2	4	5	12
Oweniidae					
Owenia sp. #1		11			
Owenia sp. #2		3	4	7	
Pectinariidae					
Cistenides brevicoma		1		1	
Pectinaria californiensis			1		
Phyllodocidae					
Eteone longa		2			
Pilargidae					
Sigambra bassi			1		
Syllidae					
Autolytus varius		1			
Unidentified					
Species No. 1				1	
Species No. 2				1	
Species No. 3				1	
ARTHROPODA					
Amphipoda					
Dexaminidae					
Polycheria sp.			1		
Gammaridae					
Melita sp.		5			
Unidentified		1			
Photidae					
Eurystheus sp.		1		1	
Microprotopus sp. #1		5			
Microprotopus sp. #2		7			

TABLE I-3 (Cont'd)

BENTHIC ANIMAL DATA
JANUARY SURVEY

Identification	Station				
	1	2	4	5	12
Phoxocephalidae					
Pontharpinia obtusidens				1	
Cumacea					
Species No. 1				2	
Species No. 2		2		1	
Decapoda					
Pinnixa hiatus				1	
Isopoda					
Idothea sp.		1			
Leptochelia sp.		1			
Tanaidacea					
Species No. 1		1	1	1	
Species No. 2		12			
Mysidacea			1		
BRACHIOPODA					
Glottidia albia				1	
BRYOZOA					
Cyclostomata					
Crisia sp. #1		f	f		
Crisia sp. #2			f		
Filicrisia franciscana		f	f	f	f
Cheilostomata					
Conopeum sp.		f			f
Unidentified			f		f
CHORDATA					
ASCIDIACEA					
Compound sp.		f			

TABLE I-3 (Cont'd)

BENTHIC ANIMAL DATA
JANUARY SURVEY

Identification	Station				
	1	2	4	5	12
CNIDARIA					
HYDROZOA					
Aglaophenia inconspicua			f		
Aglaophenia struthionides		f	f	f	f
Sertularia pulchella			f	f	
Campanularia sp.		f		f	
Unidentified		f			f
ANTHOZOA		f			
MOLLUSCA					
GASTROPODA					
Nassarius mendicus		3		2	
Olivella biplicata		1			
Oneidiella sp.		1			
Phasianella compta		1			
Morula sp.			1		
PELECYPODA					
Cardium nuttallii				1	
Macoma inquinata		10		1	
Macoma secta					f
Mya arenaria			1		
Paphia staminea			2		
Tellina carpenteri		1			
Tellina salmonea			7	25	
Tellina sp.			1		
Transennella tantilla				12	
Volsella demissus			6	3	1
Unidentified			8	22	

TABLE I-3 (Cont'd)

BENTHIC ANIMAL DATA
JANUARY SURVEY

Identification	Station				
	1	2	4	5	12
NEMATODA	73	494	6	26	
NEMERTEA		1	5	1	1
Volume of Animals (ml)	0.20	10.5	9.0	2.1	0.2
Number of Animals	79	601	71	125	5
Number of Entries	3	42	28	34	9

APPENDIX J

ACCUMULATIVE NET MASS EMISSION DATA

TABLE J-1

CUMULATIVE NET MASS EMISSION AND RUNOFF (DUE-TO-STORM)

BAKER, MARIPOSA, BROTHERHOOD, AND VICENTE DRAINAGE BASINS

(lb/acre)

Basin	Date of Storm	Runoff (in.)	Net Mass Emission (lb/acre)			
			COD	TSS	Total Nitrogen	Ortho-phosphate - P
Baker Street	4- 5 April 1969	0.29	4.45	6.13	1.29	0.15
	15 October 1969	0.16	2.07	2.39	0.12	0.15
	5 November 1969	0.50	18.5	8.93	0.85	0.06
Mariposa Street	27-28 February 1969	0.25	2.63	4.35	0.03	0.12
	20 March 1969	0.14	7.30	8.28	0.02	0.01
	2 April 1969	0.035	3.33	2.68	0.05	0.10
Brotherhood Way	14 January 1970	0.20	3.32	42.10	0.46	0.03
	15 January 1970	0.13	0.12	1.59	0.52	0.15
	23 January 1970	0.01	1.21	6.83	~0	0.01
Vicente St. (Area 1)	16 February 1970	0.58	5.18	2.83	0.22	~0
Vicente St. (Area 2)	16 February 1970	0.54	12.62	5.64	0.08	~0

TABLE J-2

CUMULATIVE NET MASS EMISSION AND RUNOFF (DUE-TO-STORM) SELBY AND LAGUNA DRAINAGE BASINS

(lb/acre)

Basin	Date of Storm	Runoff (in.)	Net Mass Emission (lb/acre)			
			COD	TSS	Total Nitrogen	Ortho-phosphate-P
Selby Street	6 November 1966	0.35	27.0	58.5	0.59	0.099
	14-15 November 1966	0.25	7.62	5.64	0.40	0.054
	20 January 1967	3.19	68.3	118	0.26	0.096
	23 January 1967	0.61	14.2	28.5	0.25	0.081
	24 February 1967	0.03	5.41	4.65	0.14	0.012
	10 March 1967	0.42	16.9	45.1	0.34	0.015
	15 March 1967	0.26	8.63	17.4	0.19	0.020
Laguna Street	10 March 1967	0.35	10.1	26.6	0.22	-
	15 March 1967	0.39	6.92	11.4	0.15	0.016

TABLE J-3

CUMULATIVE NET MASS EMISSION AND RUNOFF (DUE-TO-STORM)

BAKER, MARIPOSA, BROTHERHOOD, AND VICENTE DRAINAGE BASINS

(lb/acre-inch)

Basin	Date of Storm	Runoff (in.)	Net Mass Emission (lb/acre-inch)			
			COD	TSS	Total Nitrogen	Ortho-phosphate-P
Baker Street	4- 5 April 1969	0.29	15.4	21.1	4.45	0.52
	15 October 1969	0.16	12.9	14.9	0.75	0.94
	5 November 1969	0.50	37.0	17.8	1.70	0.12
Mariposa Street	27-28 February 1969	0.25	10.5	17.4	0.12	0.48
	20 March 1969	0.14	52.1	59.1	0.14	0.07
	2 April 1969	0.035	95.0	76.6	1.41	2.85
Brotherhood Way	14 January 1970	0.20	17.6	211	2.30	0.15
	15 January 1970	0.13	0.92	12.2	4.01	1.15
	23 January 1970	0.01	121	683	~0	1.00
Vicente St. (Area 1)	16 February 1970	0.58	8.02	4.87	0.38	~0
Vicente St. (Area 2)	16 February 1970	0.54	23.4	10.5	0.148	~0

TABLE J-4

CUMULATIVE NET MASS EMISSION AND RUNOFF (DUE-TO-STORM) SELBY AND LAGUNA DRAINAGE BASINS

(lb/acre-inch)

Basin	Date of Storm	Runoff (in.)	Net Mass Emission (lb/acre-inch)			
			COD	TSS	Total Nitrogen	Ortho-phosphate-P
Selby Street	6 November 1966	0.35	77.1	167.2	1.68	0.279
	14-15 November 1966	0.25	30.4	22.0	1.61	-
	20 January 1967	3.19	21.4	37.2	0.082	0.030
	23 January 1967	0.61	23.2	46.7	0.401	0.133
	24 February 1967	0.03	179.6	164.2	4.80	0.392
	10 March 1967	0.42	40.5	109	0.80	0.037
	15 March 1967	0.26	33.6	67.5	0.731	0.228
Laguna Street	10 March 1967	0.35	31.2	81.1	0.679	-
	15 March 1967	0.39	19.3	31.8	0.423	0.0445

TABLE J-5

CUMULATIVE NET MASS EMISSION AND RUNOFF (DUE-TO-STORM)

BAKER, MARIPOSA, BROTHERHOOD, AND VICENTE DRAINAGE BASINS

(lb/acre-inch)

Basin	Date of Storm	Runoff (in.)	Net Mass Emission (lb/acre-inch)	
			Hexane Extractable Materials (HEM)	Floatable Materials
Baker Street	4- 5 April 1969	0.29	0	0.643
	15 October 1969	0.16	0.393	0.115
	5 November 1969	0.50	3.58	0.282
Mariposa Street	27-28 February 1969	0.25	0.824	2.08
	20 March 1969	0.14	10.3	9.65
	2 April 1969	0.035	5.82	0.162
Brotherhood Way	14 January 1970	0.20	2.41	4.64
	15 January 1970	0.13	12.3	1.49
	23 January 1970	0.01	5.88	181
Vicente St. (Area 1)	16 February 1970	0.58	1.88	0.490
Vicente St. (Area 2)	16 February 1970	0.54	2.18	0.812
Selby Street*	6 November 1966	0.35	7.39	1.57
	14-15 November 1966	0.25	1.20	0.294
	20 January 1967	3.19	1.30	0.938
	23 January 1967	0.61	1.97	0.565
	24 February 1967	0.03	7.83	1.76
	10 March 1967	0.42	6.95	0.850
	15 March 1967	0.26	4.36	0
Laguna Street*	10 March 1967	0.35	5.80	1.11
	15 March 1967	0.39	2.16	0.238

*Source: Reference V-1

TABLE J-6

CUMULATIVE NET MASS EMISSION
AND RUNOFF (DUE-TO-STORM)
BAKER, MARIPOSA, BROTHERHOOD, AND VICENTE DRAINAGE BASINS

(lb/mile street)

Basin	Date of Storm	Runoff (in.)	Net Mass Emission (lb/mile street)			
			COD	TSS	Total Nitrogen	Ortho-phosphate-P
Baker Street	4- 5 April 1969	0.29	85.3	118	24.8	2.85
	15 October 1969	0.16	39.7	46.0	2.37	2.85
	5 November 1969	0.50	356	172	16.2	1.14
Mariposa Street	27-28 February 1969	0.25	72.8	121	0.82	3.37
	20 March 1969	0.14	202	228	0.61	0.31
	2 April 1969	0.035	91.9	73.4	1.40	2.57
Brotherhood Way	14 January 1970	0.20	51.5	65.2	7.13	0.51
	15 January 1970	0.13	1.86	24.8	8.15	2.38
	23 January 1970	0.01	18.8	106	0	0.2
Vicente St. (Area 1)	16 February 1970	0.58	44.2	24.1	1.85	~0
Vicente St. (Area 2)	16 February 1970	0.54	105	47.0	0.73	0.1

TABLE J-7

CUMULATIVE NET MASS EMISSION AND RUNOFF (DUE-TO-STORM) SELBY AND LAGUNA DRAINAGE BASINS

(lb/mile street)

Basin	Date of Storm	Runoff (in.)	Net Mass Emission (lb/mile street)			
			COD	TSS	Total Nitrogen	Ortho-phosphate-P
Selby Street	6 November 1966	0.35	67.7	147	14.9	2.47
	14-15 November 1966	0.25	19.1	14.1	10.1	1.35
	20 January 1967	3.19	1,710	3,150	6.56	2.41
	23 January 1967	0.61	354	713	6.10	2.03
	24 February 1967	0.03	135	124	3.61	0.295
	10 March 1967	0.42	420	113	8.32	0.383
	15 March 1967	0.26	217	434	4.72	1.46
Laguna Street	10 March 1967	0.35	222	578	4.82	---
	15 March 1967	0.39	151	248	3.32	0.35

TABLE J-8

CUMULATIVE NET MASS EMISSION AND RUNOFF (DUE-TO-STORM)

BAKER, MARIPOSA, BROTHERHOOD, AND VICENTE DRAINAGE BASINS

(lb/capita/acre)

Basin	Date of Storm	Runoff (in.)	Net Mass Emission (lb/cap/acre)			
			COD	TSS	Total Nitrogen	Ortho-phosphate-P
Baker Street	4- 5 April 1969	0.29	17.0	23.4	4.94	0.57
	15 October 1969	0.16	7.90	9.15	0.47	0.57
	5 November 1969	0.50	70.9	34.2	3.22	0.23
Mariposa Street	27-28 February 1969	0.25	30.5	50.4	0.34	1.41
	20 March 1969	0.14	84.2	95.5	0.26	0.13
	2 April 1969	0.035	38.4	30.7	0.58	1.12
Brotherhood Way	14 January 1970	0.20	21.3	270.0	2.95	0.21
	15 January 1970	0.13	0.77	10.3	3.37	0.98
	23 January 1970	0.01	7.75	44.1	~0	0.08
Vicente St. (Area 1)	16 February 1970	0.58	2.72	1.48	0.11	~0
Vicente St. (Area 2)	16 February 1970	0.54	5.56	2.48	0.04	~0

TABLE J-9

DATA DISTRIBUTIONS OF CUMULATIVE NET MASS EMISSION DATA

Number	Ranked Value of Mass Emission Coefficients (lb/acre-inch)					
	COD	TSS	TN	OPP	HEM	Floatables
1	0.92	4.87	0	0	0	0
2	8.92	10.5	0.082	0 ①	0.393	0.115
3	10.5	12.2	0.12	0	0.824	0.162
4	12.9	14.9 ①	0.14	0	1.20	0.238
5	15.4	17.4	0.148 0.38	0.03	1.30	0.282
6	17.6	17.8	0.401 ①	0.037	1.88 ①	0.294
7	19.3	21.1	0.423	0.0445	1.97	0.490 ①
8	21.4 ①	22.6	0.679	0.07	2.16	0.565
9	23.2	31.8	0.731	0.12 ②	2.18	0.643
10	23.4	37.2	0.75	0.133	2.41	0.812
11	30.4	46.7	0.80	0.15	3.58	0.850
12	31.2	59.1 ②	1.41	0.228	4.36	0.938
13	33.6	67.5	1.61	0.279	5.80	1.11
14	37.0	76.6	1.68	0.392	5.82 ②	1.49
15	40.5	81.1	1.70	0.48 ③	5.88	1.57 ②
16	52.1	109	2.30 ○	0.52	6.95	1.76
17	77.1	164.2	4.01	0.94	7.39	2.08
18	95.0 ②	167.2 ③	4.45	1.00 ④	7.83	4.64
19	121	211	4.80	1.15	10.3 ③	9.63 ③
20	179.6	683	4.80	2.85	12.3	181.0

Note: Bracketed values indicate a data set in the data distribution.

APPENDIX K

GLOSSARY OF TERMS

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GLOSSARY OF TERMS

Bypass (of combined sewage flows): the transfer of a portion of the combined sewage flows generated during wet weather conditions to an outfall system, bypassing all treatment facilities, and discharging directly to receiving waters.

Combined sewage: aggregate wastewater containing the domestic, commerical, and industrial wastewaters (dry weather flows) generated perennially and storm waters (surface runoff) and deposits scoured from the sewer and catch basins in the sewerage system as a result of surface runoff occurring during wet weather.

Combined sewage overflow: that portion of the combined sewage flow that is bypassed to the receiving water system, the remaining portion of the combined sewage flow being diverted to the dry weather system.

Diversion (of combined sewage flows): the transfer of all or a portion of the combined sewage flows generated during wet weather conditions to the dry weather sewerage system and potentially (barring downstream bypass) to the sewage treatment plant.

Dry weather flows: flows of wastewaters derived from domestic, industrial, and commercial sources that occur during both dry and wet weather conditions and that comprise the total sewage flow in the combined sewage system during dry weather conditions.

Due-to-storm: pertaining to the difference in parameter levels between that for the total combined sewage flow over the rainfall period and that for the expected dry weather flow over the same time period.

Net mass emissions: mass emissions of pollutant materials (expressed alternately in units of lb, lb/acre, lb/acre-in., etc) that are due-to-storm as defined above.

Wet weather flows: flows of combined sewage as defined above.

289.5